CONFERENCES - INTERAMERICAN

VIII INTER–AMERICAN CACAO CONFERENCE

TRINIDAD AND TOBAGO

15-25 JUNE, 1960

PROCEEDINGS

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CONTENTS

	PAGE
INTRODUCTION	1
PROGRAMME	2-3
DELEGATES AND OBSERVERS	4-13
ORGANISATION	14-15
OPENING SESSION	16-24
SEMINAR ON CACAO BREEDING AND SELECTION	25-35
REPORT ON RECOMMENDATIONS OF PREVIOUS CONFERENCES	36-38
PAPERS PRESENTED WITH SUMMARIES OF DISCUSSION	39-483
RECOMMENDATIONS	485-498
FIELD EXCURSIONS	499-510
CLOSING SESSION	510-513
LIST OF PAPERS PRESENTED	514-518

GROUP OF PARTICIPANTS :

Front Row, left to right :—
C. Navarrete S., L. J. Moreno P., L. Anleu C., W. G. C. Forsyth, A. L. Jolly, E. T. Bullard, B. G. D. Bartley, K. Doak, J. G. Rogers, G. Havord, L. L. de Verteuil, J. Leon, E. R. Moll, A. Denizard, A. Suarez R., H. Gutierrez C., A. F. MacKenzie, M. Homes, D. B. Murray, V. C. Quesnel, J. H. McLaughlin.

Center Row, left to right :—
T. E. K. Potter, V. Ho-a-shu, H. A. Williams, J. C. Ascenso, R. Muller, J. Braudeau, E. Martin, R. K. Chapman, J. Diaz, B. F. Topper, E. Quartey-Papafio, E. P. Imle, J. L. Creech, C. de Freitas, J. O. Akinwolemiwa, S. Dougdeen, W. F. K. Christian, M. Rojas, T. W. Tinsley, B. de Verteuil, G. A. R. Wood.

Back Row, left to right :—
O. Barros N., A. J. Monsalve L., J. Soria V., N. van Suchtelen, E. Ampuero P., J. Gutierrez C., C. Juste, A. M. Cruickshank, A. Helfenberger, St. G. Cooper, T. C. Khai, T. V. Than, V. N. Dinh, M. Aspiazu, W. E. Freeman, P. Sam, G. Joubert, G. K. Maliphant, J. K. Coulter, H. Kjellander, A. J. Hansen, L. Goberdhan, C. Cadet, D. R. Glendinning.

The Secretary-General, Mr. G. Havord, addressing the Opening Session.

The Premier of Trinidad and Tobago, The Hon. Dr. E. Williams, opens the Conference.

OFFICIALS AT THE OPENING SESSION :

Left to right :—
Mr. G. Bowen, The Hon. Kamaluddin Mohammed, His Excellency Sir Edward Betham Beetham, Mr. G. Havord, The Hon. Dr. Eric Williams, Mr. Louis L. de Verteuil, Mr. Armando Samper.

Delegates at the Opening Session.

Summing-up by the Technical Chairman Mr. Louis L. de Verteuil.

The Minister of Agriculture, Lands and Fisheries, the Hon. Kamaluddin Mohammed, closing the Conference.

LIST OF PAPERS

REHABILITATION

Rehabilitation for the future	L.L. de Verteuil E.R. Moll	42

FERMENTATION AND DRYING

The significance of current research on cacao fermentation	L.A. Griffiths	56
The enzymatic transformation within cacao beans during the fermentation process	A. Purr R. Springer H. Morcinek	65
La lutte contre les moisissures du cacao marchand dans l'Ouest Africain	R. Renaud	71

HORTICULTURE, PROPAGATION AND GROWTH PHYSIOLOGY

Effects of photoperiod and kind of supplemental light on the growth of Theobroma cacao	A.A. Piringer R.J. Downs	82
Efecto del almacenaje sobre la viabilidad del polen de cacao	J. Varas E.T. Bullard	92
Auxins of cacao and Cherelle Wilt	R. Nichols	100
Efectos de la polinización controlada sobre la producción del cacao	C.A. Hurtado	109
Una nota sobre conservación de semilla de cacao	C.A. Hurtado	116
A preliminary experiment on the protection of cacao seeds	A.J. Hansen R. Hunter	121
Resultados preliminares sobre el efecto de tres sistemas de poda en cacao clonal	J. Cabrera E.T. Bullard	126

HORTICULTURE, PROPAGATION AND GROWTH PHYSIOLOGY (Cont'd)

Propagación de cacao: comparación entre ramillas e injertos con relación a tres distancias de siembra	J. Gutiérrez E.T. Bullard	132
Propagador tipo "Guatemala"	Leonel Anléu	138
El uso de la tela milimetrada en almácigos de cacao	Leonel Anléu	142
Comparison of four transplanting systems with cacao	J.R. Hunter E. Camacho	144

PATHOLOGY AND ENTOMOLOGY

Comportamiento en resistencia a la Escoba de Bruja de los clones Silecia-1 y 5 traidos del Oriente ecuatoriano	E. Ampuero R. Desrosiers	156
Progresos alcanzados en el Ecuador en el estudio de selección para resistencia a la Escoba de Bruja	E. Ampuero	166
Variación en resistencia a la Escoba de Bruja, rendimiento e índice de mazorca en la progenie	E. Ampuero	174
Posible evidencia de resistencia a la Monilia Roreri Cif. y Par. en algunos clones de la Est. Exp. Trop. de Pichilingue	J. Delgado E. Ampuero K. Doak	184
Contribution à l'étude des pourritures des cabosses du cacaoyer en Basse Côte d'Ivoire durant les années 1958 et 1959	M. Delassus M. Belin P. Bonaventure	193
Preliminary studies on the use of agricultural spray oil for the protection of cacao against Phytophthora palmivora	G. Ocaña A.J. Hansen	196

PATHOLOGY AND ENTOMOLOGY (Cont'd)

Ceratostomella Wilt in cacao in Trinidad	E.F. Iton	201
A review of the problems of shot hole borer (*Coleoptera*, *Scolytidae* and *Platypodidae*) attack to cacao in West Africa	P.F. Entwistle	208
The interaction between Swollen Shoot disease and Mirids on cocoa in Nigeria	D. Kay J.F. Longworth J.M. Thresh	224
Results from preliminary studies of some aspects of the relationship of insects to cacao production in Costa Rica. A second progress report	R.D. Shenefelt M.J. Stelzer F. Lara	236
Transmission of the Cushion Gall disease of cacao	A.M. Gorenz	249
Transmission tests with Cushion Gall of cacao	L.M. Hutchins	255
An attempt to transmit Cushion Gall of cacao by bud grafting and the effect of malathion on gall development	L.R. Siller	263
A note on the relationships between flowery Cushion Gall, self-incompatibility and flower development	J. Soria	267
Cushion Gall of cacao in Trinidad	L. Goberdhan D. Ganpat	270
Cushion Gall types in cacao	L.M. Hutchins L.R. Siller	281
Reacción de diferentes clones y progenies híbridas a la Buba o Cushion Gall del cacao	R. Alvarado E. Ampuero K. Doak	290

SOILS, NUTRITION AND PHYSIOLOGY

Some relationships between soil and air temperatures in a cacao field	F. Hardy	304
Doce meses de evapotranspiración potencial en cacao	C. Navarrete	313
Cultural and manurial experiments, River Estate - A Review	G.K. Maliphant	319
Recherches sur la nutrition minérale et la fertilisation du cacaoyer, et étude des sols à cacaoyers de Côte d'Ivoire	A. Loue G. Verlière Le Lay	334
Effect of three nitrogen sources and two light intensities on the nitrogen constituents of cocoa seedling leaves of three different ages	M. Machicado D. Boynton	345
Mineral fertilisers for cocoa as deduced from the use of a test plant	M.V. Homès	355
A ton of cacao per acre?	D.B. Murray	363

BREEDING AND SELECTION

Plant breeding at the West African Cocoa Research Institute	D.R. Glendinning	374
Rendimientos de estacas, de progenies de semillas de clones UF y de semillas no seleccionadas de cacao	J. Soria L.A. Paredes	379
Clonal and fertilizer experiments in Trinidad and Tobago	A.L. Jolly L.L. de Verteuil	390
Nota sobre la sensibilidad del cacao a las radiaciones gamma y su relación con el daño causado en el núcleo celular	F. Monge	419

BREEDING AND SELECTION (Contd)

Sur les travaux de recherches effectués en 1959 à la Station du Cacaoyer de N'Koemvone pour la production des semences sélectionnées de cacaoyers	J. Liabeuf	423

EXTENSION AND DEVELOPMENT

Reforestación de terrenos no apropiados para cacao	G. Budowski	428
El cacao en Colombia	A.J. Monsalve	436
Proyecto cacao en Venezuela	M. Rojas	443
Fomento del cultivo del cacao en Guatemala	Servando Rivera	444
Extension work on cocoa in Western Nigeria	J.O. Akinwolemiwa	448
L'action des Services Agricoles de la Martinique en faveur de la culture cacaoyère	V.M. Bulle	456
Perspectives d'une relance de la cacaoculture en Guadeloupe	Albert Aurand	468
Note sur la cacao culture en Guyane Française	M. Canoz	473
Histoire de la culture du cacaoyer en Martinique	E. Goyeneche	476

THE EIGHTH INTER-AMERICAN CACAO CONFERENCE

Trinidad and Tobago

15 - 25 June, 1960

The Eighth Inter-American Cacao Conference was held at Port of Spain, Trinidad, from 15 - 25 June, 1960. The meeting was attended by ninety-seven delegates, of whom 81 were from outside Trinidad and Tobago, representing twenty-nine countries and territories, the Inter-American Institute of Agricultural Sciences of the Organization of American States, the American Cocoa Research Institute, and the Food and Agriculture Organization of the United Nations. Forty-seven observers representing various official and private organizations in Trinidad and Tobago also attended.

A special Seminar on Cacao Breeding and Selection was held at the Imperial College of Tropical Agriculture on the 13 and 14 June, 1960, in compliance with recommendations of the Sixth and Seventh Inter-American Cacao Conferences. The Seminar was attended by twenty-seven of the delegates with a special interest in cacao breeding and selection, and another ten were present as observers.

The Inter-American Technical Committee on Cacao, composed of a delegate of each of the member countries of the Organization of American States represented at the Conference, met prior to the opening session and elected the Hon. Kamaluddin Mohammed, Minister of Agriculture, Lands and Fisheries of Trinidad and Tobago, as Honorary Chairman of the Conference, and Mr. Louis L. de Verteuil, Chairman of the Cocoa Board of Trinidad and Tobago, as Executive Chairman. The Vice-Chairmen for each of the technical sessions were also elected by the Committee which met on two other occasions during the Conference.

Sub-committees were appointed to draft the resolutions and recommendations on the following subjects:

(i) The Recommendations of the Fifth, Sixth and Seventh Inter-American Cacao Conferences

Chairman: Dr. W.G.C. Forsyth

(ii) The International Register of Cacao Cultivars

Chairman: Dr. B.G.D. Bartley

(iii) Plant Introduction and Quarantine Measures

Chairman: Dr. E.P. Imle

Visits were made to the Imperial College of Tropical Agriculture; a cacao propagating station and a co-operative fermentary in Tobago; River Estate, the cacao experimental farm of ICTA; cacao areas in Central Trinidad; and to Marper Farm and La Reunión Propagating and Experiment Station of the Cocoa Board.

PROGRAMME

A special Seminar on Cacao Breeding and Selection was held at the Imperial College of Tropical Agriculture on 14 and 15 June, 1960.

Wednesday - June 15		
	10.30	Inaugural session
	14.00	Discussion of Regional Trial Programme
	19.00	Reception given by the Government of Trinidad and Tobago
Thursday - June 16		
	09.30 - 10.30	Papers on Rehabilitation
	11.00 - 13.00	Papers on Fermentation and Drying, Biochemistry
	15.00 - 17.00	Discussion of Recommendations of Previous Conferences
Friday - June 17		
	08.00 - 12.00	Papers on Horticulture, Propagation, General Botany and Growth Physiology
	13.00 - 17.00	Visit to the Imperial College of Tropical Agriculture
	20.30	"Cocorama", an evening entertainment
Saturday and Sunday - June 18-19		Visit to Tobago, by courtesy of the Government of Trinidad and Tobago. Reception given by the Government of Trinidad and Tobago on Saturday evening

Monday	**- June 20**	
	08.00 - 12.00) 14.00 - 17.00)	Papers on Entomology and Pathology
Tuesday	**- June 21**	
	08.00 - 12.00	Papers on Soils, Nutrition and Nutritional Physiology
	13.00 - 17.30	Visit to River Estate, cacao experimental farm of the Imperial College of Tropical Agriculture
	20.30	Films on Cacao
Wednesday	**- June 22**	
	08.00 - 17.00	Visit to the Montserrat and other Cacao Areas
Thursday	**- June 23**	
	08.00 - 12.00	Papers on Breeding and Selection
	14.00 - 17.00	Papers on Extension and Development
	Evening	Visit to "Made in Trinidad" Trade Fair
Friday	**- June 24**	
	08.00 - 17.00	Visit to Marper farm (breeding, selection and propagation), and Central Experiment Station (commercial cacao, experiments and propagation), Ministry of Agriculture and Cocoa Board
Saturday	**- June 25**	
	08.00 - 10.00	Approval of Recommendations
	10.30	Closing session
	20.00	Dinner given by Government of Trinidad and Tobago

DELEGATES

The Hon. Kamaluddin Mohammed,
Minister of Agriculture, Lands and Fisheries,
Trinidad and Tobago

BELGIUM	
HOMES, M.V.	Professor, Université de Bruxelles, Bruxelles
BRAZIL	
VIEIRA, Milton de Souza	Agronomist, Av. Rio Branco, 311-7°, Rio de Janeiro
BRITISH GUIANA	
HO-A-SHU, Victor	Agricultural Officer (Perennial Crops), Central Agricultural Station, Department of Agriculture
JONES, Graham A.	Chief Cocoa Superintendent, Bookers Sugar Estates Ltd., Georgetown
WHEAT, Jack	ICA Horticulturist, USOM/British Guiana, 41, Bel Air Park East, Georgetown
CAMEROUN	
MULLER, Raoul	Phytopathologiste, Directeur, Centre de Recherches Agronomiques du Cameroun, Yaoundé, Republique du Cameroun
COLOMBIA	
BARROS N., Ovidio	Jefe, Investigación de Cacao, Granja Agrícola Experimental, Palmira
CARDENOSA B., Ricardo	Coordinador Agrícola de "Cyanamid" Carr. 24, #24A 37, Bogotá
GUTIERREZ C., Humberto	Director, Cocoa Promotion Dept., Luker Chocolate Factory, Manizales
MONSALVE L., Antonio J.	Jefe, Campaña de Cacao, Ministerio de Agricultura, Bogotá

COLOMBIA (Cont'd)

MORENO P., Luis J.	Director de Entrenamiento en Cacao, Carrera 81 A - No.34A-34, Medellín
SUAREZ R., Augusto	Chief, Project 14, STACA, Aptdo. Aéreo 11048, Bogotá

COSTA RICA

DESROSIERS, Russell	Tropical Crops Adviser, USOM/ Costa Rica, c/o American Embassy, San José
MARTIN J., Ellis	Agronomist for Cacao Research, Cía. Bananera de Costa Rica

CUBA

RODRIGUEZ G., Urbano	M. Agrónomo, Sub- Estación Experimental, Baracoa
VAN DEN BERGHE, George C.	Horticultural Adviser, USOM/Cuba, c/o U.S. Embassy, Havana

ECUADOR

AMPUERO P., Enrique	Director, Estación Experimental Tropical de Pichilingue, Casilla 4040, Guayaquil
ASPIAZU, Miguel	P. O. Box 710, Guayaquil (University of Guayaquil)
BULLARD, Ervin T.	Research Adviser-Horticulturist, USOM/Ecuador, c/o U. S. Consulate, Guayaquil
BURCHARDT, Ake	Ingeniero Agrónomo, Hacienda Tres Coronas, Casilla 5656, Guayaquil
BUSTAMENTE I., Rafael D.	Ingeniero Agrónomo, Machala, El Oro (Cámara de Agricultura Litoral)
DIAZ M., Jaime	Plant Pathologist, SCIA, P.O. Box 259, Quito
DOAK, Kenneth	Plant Pathologist, USOM/Ecuador, c/o U.S. Consulate, Guayaquil
GUTIERREZ G., Jorge	Estación Experimental Tropical de Pichilingue, Casilla 4040, Guayaquil
KJELLANDER, Harry	Manager, Hacienda Clementina, Guayaquil

ECUADOR (Cont'd)	
RUBIO G., Felix B.	Horticultor, Estación Experimental Tropical de Pichilingue, Casilla 4040, Guayaquil
UBILLA C., José	Sub-Director de Agricultura, Ministerio de Fomento, Guayaquil
VILLAFUERTE, José	Horticultor, SCIA, Aptdo. 529, Quito
FRANCE	
BRAUDEAU, Jean	Institut Français du Café et du Cacao, 20 Rue Monsieur, Paris 7e
JOUBERT, Guy	Ingénieur, IFAC/Institut Français du Café et du Cacao, Ste. Marie, Guadeloupe
GHANA	
CHRISTIAN, Willie F. K.	Agricultural Officer, Ministry of Agriculture, Accra
GLENDINNING, Dalton R.	Plant Breeder, West African Cocoa Research Institute, Tafo
QUARTEY-PAPAFIO, E.	Chief Cocoa Officer, Ministry of Food & Agriculture, Cocoa Industry Division, P. O. Box 3197, Accra
GRENADA - W. I.	
CRUICKSHANK, Arnold M.	Cocoa Agronomist, Department of Agriculture, St. George's
GUATEMALA	
ANLEU C., Leonel	Jefe Sección Cacao (Agrónomo), Instituto Agropecuario Nacional, Guatemala City
ROGERS, John G.	Horticulturist (Tropical Crops), Los Brillantes, Cuyotenango, Such.
HAITI	
DENIZARD, Aurel	Agriculturist, USOM/Haiti, Port-au-Prince
DE VERTEUIL, Bernard	Cocoa Specialist, USOM/Haiti, Port-au-Prince

HAITI (Cont'd)	
JUSTE, Charles	Jefe de la Sección de Café & Cacao, Servicio de Extensión, Damien, Port-au-Prince
MC LAUGHLIN, J. Harvey	Tropical Horticulturist, USOM/ Haiti, c/o U.S. Embassy, Port-au-Prince
SAM, Pierre	Cocoa and Coffee Specialist, c/o Poté Colé, Cap-Haitien
HONDURAS	
FORSYTH, William G. C.	Scientific Director, Division of Tropical Research, United Fruit Co., Tela Railroad Co., La Lima
MEJIA B., Ulisses	Sub-Jefe, Dirección de Agronomía, STICA, Tegucigalpa
WHITE, Stephen S.	Horticulture Adviser, USOM/Honduras, c/o U.S. Embassy, Tegucigalpa
JAMAICA - W. I.	
TOPPER, Brian	Ag. Chief Agronomist, Hope, Liguanea
MARTINIQUE - F. W. I.	
BULLE, Venile	Directeur des Services Agricoles, Jardin Deschieux, Fort de France
NIGERIA	
AKINWOLEMIWA, J. O.	Ag. Principal Agricultural Officer, Ministry of Agriculture & Natural Resources, Abeokuta
TINSLEY, Thomas W.	Deputy Director, West African Cocoa Research Institute, PMB 5042, Moor Plantation, Ibadan
PERU	
HURTADO A., C. Alfonso	Ingeniero Agrónomo, Estación Experimental Agrícola de Tingo Maria
PHILIPPINES	
CUSTODIO A., Hipolito	Plant Pest & Disease Scientist, Bureau of Plant Industry, Manila

PORTUGAL

ASCENSO, José C.	Engenheiro Agrónomo, Brigadas de Estudos Agronómicos de Sao Tomé e Príncipe, Rua Rodrigo da Fonseca, 104, Lisboa

ST. LUCIA - W. I.

CADET, Charles	Agricultural Superintendent, Department of Agriculture, Castries
WILLIAMS, Horace A.	Cacao Officer, Department of Agriculture, Castries

ST. VINCENT - W. I.

DE FREITAS, Conrad	Ag. Superintendent of Agriculture, Department of Agriculture, Kingstown

SURINAM

VAN SUCHTELEN, Nicolas	Head, Agricultural Research Station, Paramaribo

TRINIDAD AND TOBAGO - W. I.

AGOSTINI, François	74, Long Circular Road, Maraval, Port of Spain (Agricultural Society)
BARTLEY, Basil G.	Plant Breeder, Imperial College of Tropical Agriculture, St. Augustine
COOPER, St. George	Technical Officer (Development), Ministry of Agriculture, Port of Spain
COPE, Frank W.	Plant Breeder, Imperial College of Tropical Agriculture, St. Augustine
DE VERTEUIL, Louis	Chairman, Cocoa Board of Trinidad & Tobago, c/o Ministry of Agriculture, Port of Spain
FREEMAN, William E.	Research Officer, Cocoa Board, Central Experiment Station, c/o Arima P. O.
GOBERDHAN, Lincoln	Plant Pathologist (Ag.), Central Experiment Station, c/o Arima P.O.

TRINIDAD AND TOBAGO - W. I. (Cont'd)

JOLLY, Arthur L.	Lecturer in Economics, Imperial College of Tropical Agriculture, St. Augustine
MALIPHANT, Gordon K.	Soil Chemist, Imperial College of Tropical Agriculture, St. Augustine
MC DONALD, John A.	Carmody Road, St. Augustine (Cocoa Board)
MOLL, Ernest R.	Chief Rehabilitation Officer, Cocoa Board, Port of Spain
MURRAY, Denis B.	Senior Plant Physiologist, Imperial College of Tropical Agriculture, St. Augustine
POTTER, Keith	Technical Agent, T. Geddes Grant Ltd., Port of Spain (Representing Plant Protection Ltd. U. K.)
QUESNEL, Victor C.	Biochemist, Colonial Microbiological Research Institute, Port of Spain
STOLLMEYER, Jeffrey B.	Baxters, Santa Cruz (Cocoa Planters Association)

UNITED KINGDOM

WOOD, G. A. Ross	Agricultural Adviser, Cadbury Brothers Ltd., Bourneville

UNITED STATES OF AMERICA

BAKER, John	Commercial Director, M & M's Candies, Hackettstown, New Jersey
CHAPMAN, R. Keith	Professor of Entomology, University of Wisconsin, Madison, Wisconsin
CREECH, John L.	Assistant Chief, New Crops Research Branch, Plant Industry Station, Beltsville, Maryland
SHAFER, Neal E.	Director of Development, Agricultural Chemicals, Cyanamid International, 30 Rockefeller Plaza, New York, N. Y.

VENEZUELA

AZPURUA, Horacio	Presidente, Asociación Venezolana de Productores de Cacao, Avenida Este 4, No. 101, Oficina 13, Caracas

VENEZUELA (Cont'd)

HERNANDEZ S., Alberto	Jefe, Campaña de Extensión Cacaotera, Región Central, Las Trincheras
JOHNSON, Frederick S.	General Manager of Narfarms Inc., Apartado 140, Valencia
NAVARRETE S., Cristobal	Profesor, Universidad Central de Venezuela, Maracay
OTTENGO L., Arturo	Vice-Presidente, Asociación Venezolana de Productores de Cacao, Avenida Este 4, No. 101, Oficina 13, Caracas
ROJAS, Mario	Supervisor, Programa de Cacao, Dpto. de Café y Cacao, Ministerio de Agricultura y Cría, Caracas
TRUJILLO, Julio	Ingeniero Agrónomo, Avenida Este 4, No. 101, Oficina 13, Caracas

VIETNAM

DINH, Vo-Ngoc	Agricultural Agent, Research in Agronomy, 121, Nguyen, Binh, Khiem, Saigon
KHAI, Tran-Cao	Agricultural Agent, Agricultural Department, 28 Mac-Dinh-Chi, Saigon
THAN, Truong-Van	Agricultural Agent, Research in Agriculture, 28 Mac-Dinh-Chi, Saigon

WEST INDIES FEDERATION

MACKENZIE, A. F.	Agricultural Adviser, Federal House, Port of Spain, Trinidad

INTER-AMERICAN INSTITUTE OF AGRICULTURAL SCIENCES OF THE ORGANIZATION OF AMERICAN STATES
Turrialba, Costa Rica

HANSEN, A. Juergen	Plant Pathologist, Inter-American Cacao Center
HAVORD, Gordon	Head, Inter-American Cacao Center
LEON, Jorge	Head, Plant Industry Department

INTER-AMERICAN INSTITUTE OF AGRICULTURAL SCIENCES OF THE ORGANIZATION OF AMERICAN STATES
Turrialba, Costa Rica (Cont'd)

MONGE, Fernando	Junior Cytogeneticist, Nuclear Energy Program
SAMPER, Armando	Director
SORIA V., Jorge	Plant Breeder, Inter-American Cacao Center

AMERICAN COCOA RESEARCH INSTITUTE

HELFENBERGER, André	Assistant to the Director of Research, Inter-American Cacao Center, IAIAS, Turrialba, Costa Rica
HUTCHINS, Lee M.	Plant Pathologist, Inter-American Cacao Center, IAIAS, Turrialba, Costa Rica
IMLE, Ernest P.	Director of Research, American Cocoa Research Institute, 1745 K Street, NW, Washington 6, D.C.

FOOD & AGRICULTURE ORGANIZATION OF THE UNITED NATIONS (FAO)

KRUG, C. A.	Agricultural Officer (Tropical Crops), FAO Latin American Regional Office (Eastern Zone), Rua Jardim Botánico 1008, Rio de Janeiro

OBSERVERS, TRINIDAD AND TOBAGO

Agricultural Society

C. de Freitas
D. Marcano

Cocoa Board

P. B. Burke
N. M. Ghany
Hon. Sir H. E. Robinson
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Cocoa Exporters Committee

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Cocoa Planters' Association

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G. de Gannes
E. de Verteuil
F. de Verteuil
I. Herrera
X. Nunes
Sir J. Mathieu Perez
L. Rostant
Capt. M. Short
F. C. Urich

Eastern Caribbean Farm Institute

L. S. Barnes
I. E. Telfer

Federation of Agricultural Co-operatives

J. C. Anthony
U. Cornelio
S. Dougdeen

Goellnicht & Stollmeyer Ltd.

W. B. Thomson

Gordon Grant & Co. Ltd.

J. P. Hutton

T. Geddes Grant Ltd.

T. E. K. Potter
A. P. McWilliam

OBSERVERS, TRINIDAD AND TOBAGO (Cont'd)

Geo. F. Huggins

P. Fahey
H. Gittens

Imperial College of Tropical Agriculture

R. F. Barnes
M. H. Breese
J. K. Coulter
L. A. Griffiths
G. E. Hodnett
J. W. Purseglove
R. Ross
V. E. White

H. E. Robinson & Co. Ltd.

G. A. Grey
F. E. Hadley

Shell Trinidad Ltd.
(for Petroleum Association)

M. Clarke
R. A. Fletcher

Thompson & Co. Ltd.

D. Farrell

Trinidad & Tobago Electricity Commission

D. E. Buxo
F. R. De Four

ORGANIZATION

Honorary President

The Hon. Kamaluddin Mohammed	Minister of Agriculture, Lands and Fisheries, Trinidad and Tobago

Executive Chairman

Louis L. de Verteuil	Chairman, Cocoa Board, Ministry of Agriculture, Lands and Fisheries, Trinidad and Tobago

Vice-Chairmen

Miguel Aspiazu (Ecuador)	Rehabilitation
William G. C. Forsyth (United Fruit Co.)	Fermentation and Drying, Biochemistry
Jorge León (IAIAS)	Horticulture, Propagation, Botany, Growth Physiology
Enrique Ampuero P. (Ecuador)	Entomology and Pathology
Denis B. Murray (ICTA,Trinidad)	Soil Nutrition, Nutritional Physiology
Basil G. Bartley (ICTA, Trinidad)	Breeding and Selection
Antonio J. Monsalve L. (Colombia)	Extension and Development

Secretary General

Gordon Havord	Head, Inter-American Cacao Center, IAIAS, Turrialba, Costa Rica

Technical Secretaries

Louis L. de Verteuil (To 15 June 1960)	Chairman, Cocoa Board, Ministry of Agriculture, Lands and Fisheries, Trinidad and Tobago
Ernest R. Moll (15-25 June 1960)	Chief Rehabilitation Officer, Cocoa Board, Ministry of Agriculture, Lands and Fisheries, Trinidad and Tobago

ORGANIZATION (Cont'd)

Liaison Officers

George L. Bowen	Permanent Secretary, Ministry of Agriculture, Lands and Fisheries
Harold E. L. Leacock	Senior Asst. Secretary, Ministry of Agriculture, Lands and Fisheries
Setu Baldeo	Acting Asst. Secretary, Ministry of Agriculture, Lands and Fisheries
Philip Newallo	Principal Officer, Premier's Office

Inter-American Technical Committee on Cacao

Chairman

Armando Samper	Director, IAIAS, Turrialba, Costa Rica

Secretary

Gordon Havord	Head, Inter-American Cacao Center, IAIAS, Turrialba, Costa Rica

ADDRESSES AT THE OPENING SESSION

Welcome by the Honourable Kamaluddin Mohammed, Minister of Agriculture, Lands and Fisheries, Honorary President of the Eighth Inter-American Cacao Conference.

I am deeply grateful for the high honour which has been conferred upon me by delegates of the Eighth Inter-American Cacao Conference in selecting me as the Honorary President of this Conference. I am also very grateful and so is my Government for the further honour which delegates have conferred on our Chief Technical Officer and Chairman of the Cocoa Board, Mr Louis de Verteuil, by selecting him as Executive Chairman of this Meeting. It is therefore a great honour and privilege for me on behalf of the Government of Trinidad and Tobago to welcome most warmly, cordially and fraternally delegates, observers and well-wishers to this the Eighth Cacao Conference.

This Eighth Meeting has been organized in cooperation with the Inter-American Cacao Center of the Inter-American Institute of Agricultural Sciences, Turrialba, Costa Rica. Arrangements began one year ago when Mr. Gordon Havord who is Head of the Cacao Center in Costa Rica and Secretary-General of this Conference paid a visit to Trinidad. It was a great pleasure for this Government to invite delegates and observers to our small but very historic and beautiful islands of Trinidad and Tobago. We note with appreciation that at this Conference we have delegates from great countries including Belgium, Brazil, British Guiana, Cameroun, Colombia, Costa Rica, Cuba, Ecuador, France, Ghana, Guatemala, Haiti, Honduras, Martinique, Nigeria, Peru, Portugal, Surinam, U.S.A., Venezuela, United Kingdom, Vietnam and from several of the West Indian islands. We also note with pleasure that delegates are also present here from the Inter-American Institute of Agricultural Sciences of the Organization of American States, and the Food and Agricultural Organization of the United Nations, two world famous international bodies.

It will be of interest to review briefly the history of these conferences. They in fact originated as meetings of the Inter-American Technical Committee on Cacao, the first two meetings being held at the headquarters, Turrialba, in 1947-49. The third was held at the Imperial College of Tropical Agriculture, Trinidad, in 1950, the number of participants being about 30. The scope of the meetings then enlarged with the Fourth Conference which was held in Ecuador in 1952. For the first time papers were presented and discussed. 73 participants met on that occasion and 38 papers were presented. The Fifth Conference was held at the Inter-American Institute of Agricultural Sciences, Turrialba in 1954 with 72 participants. The Sixth

Conference took place in Bahia, Brazil in 1956 and was attended by 148 delegates and 147 observers, of whom 54 were from outside Brazil, and 60 papers were presented. The Seventh Conference took place in Colombia in July 1958 with the total number of participants being 144, of whom 58 were from outside Colombia. Today we come to the Eighth Conference which has a record number of 81 delegates from 28 countries or territories, in addition to representatives from two famous international organisations as mentioned before, and local delegates and observers. May I say that we humbly accept the great privilege of being host country to your 1960 Conference as a tribute to our economic and political stability.

For the information of delegates and observers Trinidad and Tobago are two very small islands covering just a little over 2,000 square miles. Our population at the last census taken in April of this year revealed a population of only 825,000 persons of which 120,000 reside in the capital of Trinidad and Tobago, known as Port of Spain. We are but one of the ten units of the Federated West Indies, but small as we are our generosity, hospitality and friendliness and our goodwill to people all over the world are well known.

We have always shown great interest in the affairs of our neighbouring countries and are willing to assist in whatever way we can. In particular, we have maintained a great interest in matters pertaining to cacao research, and generally in science and modern technology.

It is an accepted fact that modern science and technology now spins the wheel of progress and advancement in every field of human activity, in every progressive country of the world. I have no doubt that this Conference is the best means to keep apace with modern developments and techniques so that all countries participating will share to their mutual benefits their knowledge and understanding, goodwill and fraternity which usually permeates the atmosphere of such important conferences; especially as your conference will deal with technical and not political issues. In this setting the decision of your last meeting to hold the Eighth Session of this Conference on the soils of Trinidad and Tobago is an indication of the confidence which you have in the Government and people of Trinidad and Tobago.

For the benefit of delegates I might mention here that the Government of Trinidad and Tobago is cognisant of the important fact that the rate of population growth all over the world makes it imperative for every country to give important and urgent consideration to agriculture, and whilst we in Trinidad and Tobago are moving steadily along the road to political independence we are very mindful of the fact that side by side with our industrial, social and constitutional advancement, agriculture must hold its rightful

and deserving place. In this respect contributions by agriculture to the gross domestic production has averaged 18%. This can be compared favourably with 28% from petroleum products.

In recent years there has been a spectacular increase both in volume and value in the oil industry of Trinidad and Tobago, but our agriculture is geared for tremendous expansion on the basis of appropriate diversification of crops. Sugar is our main agricultural crop representing 53% of the total value of our agricultural exports. Cocoa, in which delegates and observers are mostly interested, constitutes about 21% of the total value of our agricultural exports, and with heavy subsidies of farmers, technical assistance and extension management provided by the Government the cocoa industry is working steadfastly towards increased production.

Our research in cocoa in Trinidad and Tobago is greatly advanced and we are very pleased to note that the flavour of our cocoa bean is comparable to that of any other country in the world. We have also got a coconut industry which is valued at some $10 million to the country's economy per year. Our citrus industry provides over one million crates of fruit per year while the smaller agricultural industries as coffee, banana, tobacco and vegetable gardening are also playing their fair part in our economic growth. We are therefore giving agriculture its rightful place in our economy side by side with our industrial and social developments, not subordinating it at any time.

We are very anxious to have you visit our small but beautiful island of Tobago where I am sure all the delegates will be greatly impressed by the magnificent scenery, the Birds of Paradise, the Nylon Pool, the beautiful beaches, and the beauties that adorn them!

You will observe whilst you are in our midst the cosmopolitan nature of our community. In this island of ours it can be said that the East meets the West; the North meets the South; and we have them mingling and mixing together freely without any barriers on the streets, in our restaurants, our hotels and our public parks and our buses. I can say with confidence that the only set of people who are not represented in our mixed population are the Eskimoes. Indeed nowhere in the world can you find a more thorough mixture of races and religions, of vigour and vitality, of calypso and steelband, of black, white and brown living in such unrestricted harmony and tranquillity.

It is my hope and the sincere wish of the Government and the people of Trinidad and Tobago that delegates and observers will have a very fruitful Conference, and that side by side with our technical discussions you will relax in our community with utmost

freedom and happiness. We on our part will do our best in our own humble but genuine way to make your stay in our country most successful, enjoyable and memorable.

May I therefore once again formally extend to all each and everyone of you our warmest and friendliest welcome, our greetings and best wishes. Thank you once more for selecting me as Honorary President of this Conference.

The Honourable Dr. Eric Williams, Premier of Trinidad and Tobago, opening the Conference.

First let me welcome you most sincerely to the capital of Trinidad and Tobago and the Federal capital of the West Indies.

The visit here of an international organization representing the production and marketing of one of the great primary products of the world, cocoa, is an honour which at any time we would have appreciated. Today, however, we are doubly appreciative because we have in our midst the Secretary of State for the Colonies discussing with us the matter of full internal self-government for the territory of Trinidad and Tobago. And on Friday he meets the Premiers and Chief Ministers of the West Indian territories to discuss matters of great importance to our Federation which today approaches independence. You can see therefore why we and, I am sure, our people welcome your visit as a sign and portent of our early participation in the affairs of the world as an independent self-governing community.

It is not for me to attempt in any way to encroach upon the matter and scope of your deliberation. You are all doubtless experts in the general development of the industry and your own particular interest. We are also well represented by our Department of Agriculture. They,I know,have been active both in making this Conference a worthy representative of your important interest and also in presenting what we think will best advance your interest and ours.

I would like to say, however, that in our particular sphere we of Trinidad and Tobago feel that we occupy a position in the cocoa industry that is far beyond the mere size of our material contribution. The work that has been done on research at the Imperial College of Tropical Agriculture we believe to be of high scientific character, which has earned the gratitude and the approbation of all who are interested in the cocoa industry. If I may take the risk of making an invidious reference I should like to refer to the consistent, devoted and highly effective labour which has been contributed over the years by our friend Dr. Jolly. It seems that we have to make up our minds to the fact that, except in some distant Utopian future, when all the energies for research of mankind are devoted entirely to the positive and peaceful development of civilisation, the various pests which continually threaten our industry will always be with us. The moment you have discovered the cure for one pest, either another turns up or the one that you conquered reorganises its forces and counter-attacks. So that until the happy day of universal peace and harmony I am glad to assure you that the Imperial College of Tropical Agriculture will continue to do its work with the approval and assistance that it may need from my Government, I am sure from the Federal Government also, and from all those countries which are represented here.

You may have heard, but I have no hesitation in repeating, that the Imperial College of Tropical Agriculture is to be incorporated into the University College of the West Indies as the Trinidad branch of the University College. Thereby we hope that the reputation which it has gained already for the work that is being done in research for the benefit of the industry will increase and expand according to your needs and desires.

The cocoa industry has a long history in this particular territory. It has had its ups and downs, but despite the pressure from new sources of supply, we feel that with the particular quality of the cocoa that we produce we have a place on the world market that is assured, as assured that is to say as it is possible to be in the uncertain circumstances which attend the production of primary products.

And this brings me to the second point which I wish to refer to here today. The position of primary products on the world market today is, as it has been for many years, to put it mildly, uncertain. In economies such as ours, which have so many decades of leeway to make up, this uncertainty is a matter of particular concern to the plans and projects of governments. The Imperial College of Tropical Agriculture is not a West Indian institution, at least it was not at its inception, and today although it is now becoming attached to a West Indian institution you can be confident that that disinterested concern for the development of

science for the benefit of the industry on a world scale which has so far distinguished it will not in any way decrease. It seems to me that it is possible for us now here in the West Indies to take some prominent part in the research and projects which can lead to some stabilisation in the production and marketing of our industry. This is particularly so, it seems to me, because there has recently been appointed as Principal of the University College of the West Indies Dr. Arthur Lewis, who, both in the theory of political economy on a world scale and his experience in various underdeveloped countries and at the United Nations, is particularly fitted to help in the guidance and initiation of any such projects of which I am sure your minds are very full. We all of us simply must be able to produce and to plan in such a manner as to reduce if not entirely to get rid of that uncertainty and sometimes steep decline in prices which is one of our greatest problems.

I would like to think that, despite the dominant position in the market which is held by the producers in Ghana, and I am informed is being attempted in Brazil and other parts of Africa, we will not only improve our quality and quantity but will earn yet another place for ourselves in that common work which is represented by your Conference here today.

I may have spoken as if the stabilization of prices of commodity products is of interest and concern only to us. I need not tell a conference of this kind that that is not so. We are moving into a world where the stabilization and ordered progress of any product, primary or otherwise, will be of benefit to producers, manufacturers and consumers alike.

There is one more point on which I should like to touch. We in the West Indies and some of you here at any rate are doubtless concerned about the difficulties which threaten us, or perhaps I should say which face us, with the inclusion in the Common Market of Europe of primary producers in other parts of the world. That question, I have no doubt, will play some part, however indirect, in your deliberations. I, like many others, await with interest your findings and your conclusions if even these are tentative. Let me say this, however. We in the West Indies are now approaching the period when with Independence we shall enter into entirely new relations with the metropolitan powers. I think that I can take the liberty of saying that a recent and in fact not yet completed event gives us a happy augury for the future of those relations under the new dispensation. Many of you here are in the same position. Although many influences and interests will be exercising their forces upon the adjustment of this very difficult problem yet there are certain intangibles which it is up to all participants to make as concrete as possible.

I refer to such a matter as the long association between metropolitan and formerly colonial states which are entering upon a new stage which it behoves both protagonists to handle in such a way as would coincide with the aspirations and interest of "one world".

I refer also to that sense of unity, common difficulties and common efforts to achieve the modern community, which is a force for unity and collaboration among all of us who are new nations primarily interested, as for some time we will continue to be, in the production of primary products. I believe and I hope you will agree with me that however sharp may be the conflict of interests, they have the best possibility of being harmoniously resolved if such considerations as I have put before you are never lost sight of by those who have to deal with them. I hope that I shall have your agreement if I suggest that in the work which you are about to undertake such consideration be never absent from your plans for today and for tomorrow.

Let me once more wish you success in the arduous and important task that you have to perform. We of Trinidad and Tobago will take our part in that, but to the extent that you need relaxation and refreshment in order the more strenously to approach what you have to do, it will be our sole responsibility to deal with this, and we hope we shall do so in such a manner that it will not be too long before you will once more visit us for this or similar purposes.

I now formally declare open this Eighth Inter-American Cocoa Conference and wish you all success in your deliberations.

The closing remarks by Mr. Armando Samper, Director of the Inter-American Institute of Agricultural Sciences of the Organization of American States.

In bringing to a close this opening session of the Eighth Inter American Cacao Conference, allow me to touch briefly on the strategy of regional cooperation.

People, not things, are needed to build programs. Einstein, the greatest scientific mind of our times, used only two tools to work out his theory of relativity: his brain and a pencil to jot down his famous equation. Things, to be sure, are needed too. Modern research requires money for land, money for buildings, money for equipment, money for materials. But material things are useless without well trained and dedicated people.

Tradition, resources, organization make up the institutions required to give the research people a base to engage in their research discoveries. Organization, however, should mean not so much lines of authority and administrative control as the means to plan programs properly and conduct research successfully. If we have people and institutions, we can develop programs to solve problems. Simple as this sounds, however, research results often fail to materialize because one or more of these four basic elements is lacking or is weak.

Sometimes the people we have lack the training required to carry out the quality of research needed or lack the creative imagination essential to find new approaches to the solution of problems. Other times, our institutions do not offer the proper environment for research people to work with the freedom they need and give them the support they are entitled to receive. Still other times, we fail to identify real problems and develop unbalanced programs that cannot produce the solution to the problems.

Doing research is difficult even when all facilities are available. Doing research in the tropics, where usually well trained people are scarce, the institutions have very limited resources, and the problems are baffling in their complexity, requires great ingenuity and patience. But if doing research is difficult, applying the results of research is often just as difficult. Yet, quite often we underestimate the difficulty of communicating the results of research and consider to be efficient methods that should be unacceptable.

This series of meetings represent, perhaps, our most successful regional effort to improve communication among research workers and promote the application of research results concerning an important tropical crop. We have come a long way from the time in 1947 when a handful of professionals concerned with the improvement of cacao production and processing in the Western Hemisphere met at Turrialba. They met as the newly established Inter-American Technical Committee on Cacao, created by the Inter-American Economic and Social Council of the Organization of American States. They launched this regional cacao program through the Inter-American Cacao Center, an agency organized within the Inter-American Institute of Agricultural Sciences of the OAS with support from the American Cocoa Research Institute of Washington, D.C.

But research knows no boundaries. Soon, this work, so heavily underscored at the beginning by the words "Inter-American", expanded its scope to cover the Western Hemisphere and, more recently, the main cacao producing regions of the world. This is as it should be in dealing with tropical crops. Since that time in 1947, over 600 cacao workers have met eight times about every two years.

They have met at Turrialba and many of the main producing areas in the Western Hemisphere, under the auspices of the Governments most keenly concerned with cacao production and at the institutions most actively engaged in cacao work.

The Inter-American Cacao Conferences have become the recognized medium to report on the achievements of research and exchange concrete experiences and ideas for the communication of research on a regional basis and the application of research at the national level. These conferences have been an effective regional tool. Part of the success has been due to the existence of a working technical secretariat. The Inter-American Cacao Center has given dynamic impulse and continuity to this joint effort for common action. For the continued support of the Center, the Inter-American Institute of Agricultural Sciences of the OAS is deeply indebted to the American Cocoa Research Institute of Washington, D.C.

Only part of the success, however, has been due to the Inter-American Cacao Center. We have provided the means, but the cacao institutions within and without the Western Hemisphere have provided the rest. And you, the cacao workers, as the basic and essential element of all programs, are responsible for the success of this regional program.

In closing this session, I wish to express the deep appreciation of the Inter-American Institute of Agricultural Sciences of the OAS to the Government of Trinidad and Tobago for having served as a most gracious host for this meeting; to the Imperial College of Tropical Agriculture for making available to us the facilities of the College for a fruitful Seminar on Cacao Breeding and Selection; and to the Ministry of Agriculture, Lands and Fisheries for their unreserved cooperation in planning and carrying out this meeting. The interest and hospitality of the Ministry was clearly evident to all of us from the moment we stepped down from the airplane to be met and brought to our quarters. Finally, I wish to thank you, the delegates, for having taken time out from your busy schedules of important work to discuss common problems and promote the improvement of a key crop in the tropical areas of the world.

SEMINAR ON CACAO BREEDING AND SELECTION

13 - 14 June, 1960

Report by B.G.D. Bartley

Through the discovery a few years ago of new techniques for the development of cacao varieties the scope of cacao breeding was considerably enlarged and it became apparent that increased attention would be given to this field of research. At the Sixth Inter-American Cacao Conference which was held at Salvador, Brazil in 1956 it was decided that the progress of cacao breeding programmes, particularly in those countries where such research was being initiated, would be advanced by a meeting of cacao breeders. At this meeting it was felt that plant breeders and persons engaged in research in allied subjects could exchange information on their own breeding programmes and this would benefit those who lacked experience in cacao breeding.

When plans were being drawn up to hold the Eighth Inter-American Cacao Conference in Port of Spain it was felt that the Cacao Breeding Seminar could be held in conjunction with the Conference. Invitations were sent to those interested in cacao breeding and others who could contribute to the discussions.

The Seminar was held on June 13 and 14, 1960 at the Imperial College of Tropical Agriculture, St. Augustine, Trinidad at the invitation of the Principal of the College.

The Seminar was attended by 27 participants and 10 observers from many cacao growing countries.

The original arrangements for the Seminar envisaged the holding of eight sessions each devoted to a topic of cacao breeding. Each topic was to be introduced by a review which would provide some background information on the topic. The topics discussed and the speakers invited to present the reviews were as follows:

1. Cacao populations and single plant selection - Dr. J. Soria, Inter-American Cacao Center, IAIAS, Turrialba, Costa Rica

2. Sexual methods of breeding, breeding systems and utilization of heterosis - Dr. B.G.D. Bartley, ICTA, Trinidad

3. Quantitative inheritance - Mr. D.R. Glendinning, WACRI, Ghana

4. Field experiments - Mr. G. Hodnett, ICTA, Trinidad

5. Seed production and plant distribution methods - Dr. E.T. Bullard, Estación Experimental Tropical, Pichilingue, Ecuador

6. Disease resistance - Mr. W.E. Freeman, Ministry of Agriculture, Trinidad

7. Genetic studies, incompatibility systems and pollinations - Dr. F.W. Cope, ICTA, Trinidad

8. Breeding for flavour and quality - Dr. W.G.C. Forsyth, United Fruit Co., Honduras

The Seminar was opened at 8.30 a.m. on June 13, 1960 by Mr. G. Havord, Secretary General of the Inter-American Cacao Conference, who introduced the participants. Dr. B.G.D. Bartley was appointed the Secretary of the Seminar.

The participants were welcomed to the Imperial College of Tropical Agriculture by Dr. F.W. Cope on behalf of the Principal of the College who was unable to attend.

The Seminar was held in four half-day sessions each presided over by a chairman. The chairmen were Dr. F.W. Cope, Mr. C.A. Krug, Dr. J. León and Mr. D.R. Glendinning.

A display of cacao mutants and genetic research conducted by the cacao breeding section of the Regional Research Centre, Trinidad, was held during the Seminar.

In his opening remarks on the subject of cacao populations Dr. Soria stated that knowledge of cacao populations was important because it is from these populations that the genotypes used for breeding are derived. These populations may be natural ones, that is, those in which selection by man has not operated, and cultivated populations where selection by man has been effective in changing the frequencies of certain genes. In cultivated populations each plantation might be considered a distinct population for selection purposes. There is sufficient variability in most populations to enable some selection to be carried out.

Until recently, breeding work has been based on the isolation of individual trees which are propagated vegetatively. Selection is more effective in populations where genetic variability is high and for characters with high heritability. In less variable populations a larger number of initial selections are needed than in populations with high variability. Characters to be selected and the criteria of selection will depend on the requirements of each producing country.

During the discussion Mr. Glendinning expressed the view that in breeding for yield it did not matter what comprises a population since there was a whole world of populations to select from. Dr. Soria pointed out that genes controlling specific

characters might be obtained from specific populations.

Mr. Freeman was of the opinion that selection for yield could commence when the trees are four years of age. However, he was unable to present any evidence of a relationship between the yields of trees at four years of age and the yields of their progeny.

The problems of selection in old cacao fields were raised by Dr. Soria. Some factors of error such as age and size of trees are introduced which are unimportant in young plantings. Dr. Bartley described the distributions of yields of single trees in old plantations. In all cases these distributions are not normal, there being an excess of low yielding trees. Similar distributions, though not nearly as skewed, are obtained in yields from mono-clonal plantings as cuttings. These distributions are mainly the result of environmental effects and contribute to the low heritability for yield.

At WACRI it has been found that yields of selections planted as clones are not related to the yields of their selfed progeny.

It was pointed out that in certain cases high yields are related to vigour in the early stages of development. Growth in later years and yield are sometimes dependent on the rate of growth at the start of a plant's life. Generally faster growing trees begin to bear at an earlier age than slow growing trees. The possible use of growth as a criterion of selection is being studied at WACRI and ICTA.

On the other hand, it was explained that some high yielding clones grow very slowly at the beginning. Selection for early bearing is no guarantee of yielding ability in later years. Mr. Glendinning suggested that the yielding ability of a clone might be determined by the proportion of pods borne on the branches of the mother tree from which it was selected. Dr. Bartley stated that some trees appear to bear all their crop on the branches.

The utilization of the results of individual plant selection was discussed. Many of the participants stated that their experience showed that seedlings were able to withstand adverse conditions better than cuttings and could be established more easily in certain areas. In general, more interest was shown in varieties produced from seed than in clones.

Owing to the ease with which uniform populations can be created by the use of mono-clonal plantings the necessity for uniformity was considered. There was a general agreement on the need to maintain some variability in cacao populations. Usually growers are not interested in uniformity. Dr. Desrosiers

emphasized the importance of maintaining genetic variation as a safeguard against the spread of diseases. The effects of the introduction of new diseases in certain populations is well known. Dr. Cope also pointed out the need for variability in certain populations in order to maintain the traditional flavours of those populations. He also mentioned the large differences observed in the performance of clones grown in different locations. It was explained by Mr. Glendinning that open-pollinated varieties could be less subject to environmental interactions than uniform varieties such as clones.

Mr. Krug of the Food and Agriculture Organization of the United Nations presented the resolutions of the FAO Technical Cacao Conference held at Accra in February 1959 with respect to cacao collecting expeditions and germplasm collections in order to obtain the views of plant breeders. The FAO was considering ways and means of organising these expeditions through the ad hoc Technical Advisory Committee. Dr. Bartley mentioned that this subject had been discussed at previous conferences and that experience had shown that it would be better to encourage individual countries to make their own collections and any expeditions should be on a small scale. The difficulties of obtaining cooperation in this respect from certain governments were mentioned. It was felt that some collections should be made in Mexico and other countries where the original populations were disappearing. It was emphasized that explorations should be organised by persons with knowledge of cacao types.

In his opening remarks on the topic of sexual methods of breeding in cacao Dr. Bartley stated that in its simplest form the production of varieties from seed depended on:

1. Finding, producing and evaluating parents, and

2. Choosing the appropriate combinations of these parents.

At the beginning of a breeding programme a form of Mass Selection could be used to raise the average level of production in a population. This would be accomplished by cutting out all undesirable trees in a field and allowing the few good trees remaining to intercross. Seed from these crosses would form the new planting material while the selections were being tested for use in producing improved varieties.

Selected individual trees may be used as parents either as clones or as inbred lines. In populations which are homogeneous it may be possible to obtain pure line varieties by little inbreeding. In most cases the best method of utilizing the selected parents is through bi-clonal hybrids or single crosses.

In heterogeneous populations there will be a need to reduce heterozygosity. This is accomplished by inbreeding and selection.

This procedure will eliminate undesirable genes from the population. The performance of bi-clonal hybrids among ICS clones has been poor in comparison with the best clones. The reasons for this are that the parents were not selected for their breeding behaviour and segregation for other characters reduces the potential yielding ability of the progeny.

Possible parents can only be evaluated by test crossing. For Trinidad conditions two types of tester parents are being sought; (a) homozygous self-fertile clones and (b) self-incompatible clones. Phenotypic expression is no indication of the breeding value of a clone. One of the best Trinidad clones, ICS 95, has been shown to be a poor parent, while ICS 53, which is a low yielding clone, shows promise as a good parent. Similar observations were made by Mr. Freeman, Mr. Glendinning and Dr. Soria.

Successful use of bi-clonal combinations will depend on the utilization of heterosis. Heterosis for yield and growth has been shown to occur in cacao. This is shown as a depression in vigour on inbreeding and an increase in vigour in certain hybrids. General combining ability appears to be strongly inherited in cacao and this should be used as a criterion of selection of parents.

Mr. Glendinning said that in Ghana a relationship had been obtained between early vigour and yield. Later he stated that selection was being practised on early vigour. Two problems arose with selection at this stage. These are the effect of seed size and spacing on early growth. Dr. Cope emphasized that in view of the relationship between early vigour and yield the question of early testing was an important one.

The question was asked whether crosses among widely different types were responsible for hybrid vigour. Mr. Freeman said that crosses among Amazon types gave higher yields than crosses between Amazon and Trinitario types. Mr. Glendinning stated that hybrids between different Amazon families were superior to crosses within the Parinari and Nanay populations.

The importance of selecting for seed size was discussed. Seed size is not an important character to be considered for the market. However, Dr. Bartley said that evaluation of yield potential of progenies was made difficult through wide segregation for seed size and he suggested that the range of seed size be reduced by selection against small seeds. He felt that there should be a more critical examination of the inheritance of size and other seed characters and that it was proposed to start intensive research into these factors at ICTA.

Mr. Glendinning stated that the inheritance of yield is the most important factor to be considered. The yield of a tree is the

product of many factors. These are: number of pods, weight of pods and the dry weight to fresh weight ratio in any given case. The number of pods produced is determined by flower production and Cherelle Wilt. Pod weight is affected by the number of pods produced.

Dr. Bartley mentioned that a negative correlation existed between pod size and number of pods produced. There was also a good correlation between yields in successive years and this appeared to be determined by the location of the trees rather than by genetic differences.

There was a very interesting discussion of the methods of producing bi-clonal hybrid seed. Dr. Bullard reviewed this topic and listed the various methods by which seed may be obtained on a large scale. These methods include hand pollination and natural pollination in isolated crossing blocks which is possible where one or both parents is self-incompatible. Another possible method is by top-working certain trees in established plantings of one of the parents.

Hand pollination was considered to be the most efficient method of seed production. The relative cost of this method is low and an increase in the efficiency of hand pollination in terms of the number of fruits set per man-day. One problem in hand pollination is the need for covering the flowers. This could be avoided by the use of insecticides to kill the pollinating insects. It was suggested that other methods of flower protection could be investigated.

The problems involved in the use of crossing blocks are the dangers of contamination by foreign pollen and mixed pollination. It was advised that crossing blocks should contain many more trees than would be required to produce the quantity of seed needed for planting. The surplus trees would serve as protectors for the trees in the centre of the block from which the seed would be harvested. Mr. Cope mentioned that prevailing wind currents should be taken into account in designing crossing blocks.

Dr. Glendinning said that in Ghana the policy was to establish crossing blocks in advance of the decision to distribute hybrid varieties. This measure would save the time that normally would elapse between the date on which it was decided to distribute a variety and the time the seeds became available from the crossing block. He was of the opinion that trees should be spaced at 8' to 10' and that the ratio of female to male trees should be 3 or 5 to 1. He also stated that hand pollination did not increase the number of pods produced.

Mr. Freeman stated that with hand pollination it was possible

to obtain an out of season increase in pod production.

Dr. Bollard also mentioned the possible use of gametocides in assisting cross-pollination. This technique could enable hybrids of self-compatible clones to be produced by natural cross-pollination. There is the possibility that selfed plants may be obtained and these may be eliminated by rogging. Dr. Bullard was also of the opinion that studies on pollen storage were essential and said that he had undertaken some investigations on this subject and suggested that freeze drying of pollen be studied.

At the present time there is a considerable movement of planting material, particularly of seed, between countries. The Seminar discussed the various methods of packing seeds and the results obtained. Mr. Freeman stated that variable results were obtained when charcoal was used and that better germination was achieved with seeds packed in damp coir fibre when the pulp had been removed. Dr. Soria stated that the method proposed by Dr. Alvim at the 7th Inter-American Cacao Conference seemed to be the best. However, Dr. Hansen said that workers objected to using lime and that work carried out by him and colleagues using sawdust as a packing medium on fungicide treated seeds in plastic bags gave promising results. Most workers have experienced difficulties due to delays in transporting seeds and it was suggested that steps be taken to reduce these delays.

With regard to the transportation of cuttings Mr. B. de Verteuil said that he had tried various methods of packing cuttings. He suggested that the best method was to take the rooted cuttings straight out of the bin and pack them in polythene bags.

A short session of the Seminar was devoted to the role of field experiments in plant breeding investigations. In his introductory remarks Mr. Hodnett dealt with some of the problems of designing field experiments with tree crops. He said that many of the experimental designs used for annual crops were not suitable for tree crops. The more robust designs should be used for the latter. These include the randomised block design which is the simplest to use provided there is sufficient replication. He dealt with plot sizes and plot shapes. The larger plots are more accurate but with limited space it may be necessary to use small plots with more replication. The minimum number of trees per plot in a trial should be 8 or 9.

Mr. Hodnett also discussed the use of relationships between characters, trials at different locations, experiments with other treatments superimposed on varieties and the use of guard rows.

One of the problems which occur in cacao experiments is that due to differences in competition. This is observed as competition between varieties and reduces the efficiency of small plots. Competition effects are also obtained when trees are missing.

Mr. Glendinning and Dr. Bartley mentioned that they had observed that coefficients of variation were higher in plots with low mean yields than in plots with high mean yields.

A question was asked about the plot size to be used in genetic experiments. It was stated that plots in these experiments could contain as many as 36 trees.

The session on breeding for resistance to cacao diseases attracted much attention among the participants. The two major fungus diseases, caused by Phytophthora palmivora Butl. and Marasmius perniciosus Stahel, were discussed in detail. The proposals of the FAO for establishing a centre for studies of resistance to Phytophthora palmivora were mentioned. Dr. McLoughlin warned that owing to the nature of the pathogen breeding for resistance might not be successful.

The existence of different strains of Black Pod pathogen in West Africa was reported by Mr. Glendinning. He also stated that the rate of lesion spread in different types was not related to pod losses in the field.

Two possible systems of resistance to Black Pod were suggested by Dr. Hansen. These are hypersensitvity and the action of several genes of small effect which would retard the spread of infection in the pod. Variability in field susceptibility had been observed in Trinitario type trees. Crosses had been made among these trees and the differential reactions of the progeny would be studied. A possible method of testing resistance was the inoculation of pod media described by Orellana.

Dr. Bartley mentioned that unwounded pods of SCA clones developed no infection but that this resistance was not evident when the pods were wounded and damaged pods of these clones appeared to be just as susceptible as those of the Trinidad clones.

From the discussion it was apparent that no sources of resistance to Black Pod disease are known.

The position with respect to breeding for resistance to Witches' Broom disease is different to that in the case of Black Pod disease. A source of resistance to the former has been found in the SCA clones which are now the basis for a great deal of investigation.

Mr. Freeman reported on the work of the Cocoa Board of Trinidad and Tobago in combining resistance with other agronomic characters. (Further details of this appear in the notes on the visit to Marper Farm).

Of special interest was the observation made concerning the differences in disease resistance obtained in reciprocal crosses involving ICS 1 and SCA 6. The resistance was higher in the progeny when the Amazon parent was the female.

There also appeared to be an association between the intensity of vegetative brooms and pod infection.

Mr. Aspiazu described his association with Dr. Pound in the attempt to discover sources of resistance to Witches' Broom disease in Ecuador and the history of the disease in the country. He felt that other sources of resistance were available but they were overlooked because they were not of the Cacao National variety.

It was suggested that breeding for resistance would be enhanced if the parent tree of the SCA clones could be rediscovered.

Dr. Bartley reviewed the work on resistance which was being conducted at the Imperial College of Tropical Agriculture. A method of producing spores was developed because the fungus did not produce fruiting bodies in artificial media. Two lines of work are being pursued; (a) a study of the inheritance of resistance by backcrossing the susceptible x resistant progeny to susceptible trees, and (b), the isolation of self-compatible trees which were homozygous for the genes controlling resistance, by artificial inoculation of progeny of sib-crosses. In addition other possible sources of resistance are being investigated. One of these is P 12 (Pound 12 from Peru) whose progeny show a reaction to artificial inoculation different to that of the progeny of SCA 6.

Ing. Hurtado stated that the progeny of P 12 grown at Tingo Maria, Peru had not shown signs of infection up to now.

Dr. Cope mentioned the dangers of the existence of physiological races of Marasmius perniciosus. Dr. Bartley stated that evidence of the existence of physiological races had been obtained from observations on other Theobroma species. There was evidence of possible differential reaction in T. cacao genotypes but this had not been investigated as yet. Dr. Doak described the method which could be employed to distinguish physiological races in different countries. This would involve the exchange of standard seed material and subsequent artificial inoculation.

Observations made in Ecuador on pod infection of 52 selections indicated differences in susceptibility to Monilia roreri. Further investigations are in progress.

A brief mention was made of genetic differences in mortality from attacks of Ceratostomella fimbriata. Lack of time did not allow discussion of resistance to this and other diseases.

The seventh session of the Seminar was devoted to several phases of the genetics of cacao about which a great deal of information has become available in recent years. In introducing this session Dr. Cope described the studies on the inheritance of qualitative characters which were in progress. Among the characters which are being studied are those controlling anthocyanin pigmentation in various parts of the plant, dwarfism, albinism, absence of the jorquette, pod shape, especially the pentagona type, and compatibility.

The small amount of available information on the cytology of cacao was reviewed. Problems involved in cytological investigations are the small chromosomes and the presence of tanin-like substances which make staining difficult.

Cacao possesses an unique system of self-incompatibility. Incompatibility is brought about by the absence of fusion of gametes carrying similar alleles. The proportion of non-fusion ovules varies with the type of mating. Three ratios of fusion to non-fusion ovules are possible; 1:3, 1:1 and 0:1. In compatible matings fusion takes place in all ovules in the ovary. Self-compatible trees will mate with all other genotypes. Self-incompatibility is controlled by a series of multiple alleles at one locus and by two other complementary loci.

Dr. Cope said that all cacaos should be considered as belonging to one species as all types and varieties hybridise freely and produce viable offspring.

Dr. Soria referred to the wide range of bean pigmentation which was observed and stated that three genes could be postulated as controlling bean colour. According to most experiences, Dr. Bartley said, bean colour and pod colour were inherited independently. The most striking example of an association between the two characters was in ICS 62 where seeds with white cotyledons produced only non-pigmented plants and seeds with purple cotyledons produced only pigmented plants.

A question was asked about the possibility of double embryos occurring in cacao seeds and Dr. Bartley confirmed that double embryos were obtained.

Insect pollination is most important in cacao, the majority of flowers being pollinated in this way. Previous estimates of cross-pollination showed considerable variation, the range being from 18 to 100 percent. Estimates of the distance over which pollen is transferred also varied widely, some investigators being of the opinion that pollination took place between adjacent trees only, while in other cacao there is evidence that pollination occurs over long distances, as is the case in Ghana. Evidently, the proportion of flowers which are cross-pollinated and the pollination distance

differ according to the country and specific conditions.

In some countries breeding for flavour and quality occupies an important place in improvement programmes. In his review of the position with regard to breeding for these characters Dr. Forsyth emphasized that qualities could only be assessed subjectively at present. The problems faced by those who were engaged in breeding for quality concerned the assessment of flavours and the fermentation of small quantities of beans.

Present tasting methods were developed to control blending techniques in chocolate manufacture. New genotypes have flavour profiles which are completely different to the uniform production batches with which the tasters are familiar. The results obtained in assessing the new genotypes are not comparable with previous samples.

The flavour of a bean is genetically determined but curing methods can change flavours considerably. With new genotypes under examination only small quantitites of beans are available for examination. If small scale fermentation techniques are used, considerable variation between repetitions must be expected. Three methods of small-scale fermentation are being used.

1. The controlled environment method which attempts to imitate the conditions obtained in normal fermentation. This involves controlled heating and aeration of beans in thermos flasks. The difficulties involved have led to the development of complex designs which are cumbersome to use.

2. The aseptic method in which the pulp, the source of microbial action, is removed and the beans are cured under aseptic conditions. This method appears to develop proper flavour profiles but has the disadvantage of requiring thermostatic control.

3. The shallow layer tray method uses microbial activity but variations in flora are reduced by spreading the beans in a layer. It was suggested that this method is the best for general use.

Bean pigments have been shown to play no part in the development of flavours. Flavours are determined by other chemical constituents of the beans. These constituents are unknown at present so that chemical analysis cannot be used as a tool in flavour assessment.

The experiences which breeders have had in obtaining flavour assessments were described. Considerable variations in manufacturers opinions are obtained and results of assessments are often of little value in flavour investigations. It was agreed that unless satisfactory methods of flavour assessment are employed, breeders have little choice but to ignore this character apart from discarding genotypes which produce definite off-flavours.

REPORT ON

RECOMMENDATIONS OF PREVIOUS CONFERENCES

The Secretary General reviewed the recommendations of the last three Inter-American Cacao Conferences and the progress which had been made in their implementation. At the Fifth, Sixth and Seventh Conferences sub-committees were appointed to consider a series of specific topics, and to formulate recommendations for adoption by the whole Conference. In the majority of cases the Inter-American Cacao Center had been given the responsibility for carrying out the recommendations. Owing to the number of recommendations and the limited facilities of the Cacao Center, it had not been possible to carry out all of them. Several recommendations were repeated from Conference to Conference.

The recommendations fell into three main classes:

1. Recommendations to establish committees to conduct further studies or surveys. These had been found impractical, since it was rarely possible for these committees to meet between Conferences.

2. Recommendations that attention be given to specific problems or research be carried out on specific subjects.

3. Recommendations to establish new centers or services, to provide certain training facilities, or to publish or collect certain information.

The following recommendations for specific activities have been carried out:

VII Conference

A. 6. The Secretary General attended the First FAO Technical Meeting on Cacao in February, 1959 and is serving on the "ad hoc" committee appointed by FAO to assist in carrying out the recommendations of that meeting.

C. 1 and 2. The International Register of Cacao Cultivars is being developed and 21 clones have been fully described. An example was shown.

C. 5. A special Seminar on Cacao Breeding and Selection was held immediately prior to this Conference.

D. 3. A booklet demonstrating methods of curing cacao is being prepared by FAO, obviating the need for further action on this recommendation.

VI Conference

A. 1. Experimental layouts for comparisons of clones and progenies have been designed and distributed.

A. 3. Field tests of clones and seedling progenies are being stimulated by means of the Regional Trials Program of the Inter-American Cacao Center.

A.C. 5 A Symposium on the Ceratostomella-Xyleborus complex was held at the VIII Conference.

E. 1. A report on the replies to a questionnaire on curing practices was presented at the VII Conference.

V Conference

Dr. Ostendorf of the Agricultural Experiment Station, Surinam, presented the technique for identifying clones by floral characteristics at the VI Conference.

Dr. Desrosiers prepared a survey and map of the distribution of diseases and pests in Tropical America for the VI Meeting.

A supplement to the Bibliography on Cacao Literature prepared by IAIAS has brought this up to 1 July, 1958.

Action on the following recommendations is in progress:

VII Conference

A. 3. The recommendation to establish a Center for the study of Phytophthora palmivora was supported by the First FAO Technical Meeting on Cacao in February, 1959.

A. 4. Low volume sprays of fungicides and shorter cycles of application are under study at Turrialba.

A. 9. A survey of the extent and importance of Cushion Gall has been carried out.

C. 3. A germ-plasm collection is to be established at the Federal Experiment Station, Mayaguez, Puerto Rico, initially under an agreement between the American Cocoa Research Institute and the U.S. Department of Agriculture.

C. 4. Interested botanists have been contacted with a view to preparing a taxonomic study of the genus Theobroma, but funds are needed.

E. 2. A beginning has been made in collecting information on soils, vegetation, geology and meteorology of areas producing or capable of producing cacao. When more information is available, a list will be published in "Cacao".

VI Conference

C. 1. See VII Conference, A. 4. above.

No action has been taken on recommendations to establish further sub-committees, or on the following:-

VII Conference

A. 8. The establishment of a Center for the identification of the neotropical insects.

D. 8. Soliciting the assistance of chocolate manufacturers in establishing criteria of quality which will permit the grower to judge the acceptability of his product to the manufacturer.

E. 1. The establishment of graduate short-courses on soil surveys, field experimentation, and laboratory techniques.

F. 6. That the first Sunday in June of each year be designated as "International Cacao Day".

G. 1. The acquisition of information on all long-term field experiments in progress.

G. 2. The collection of data from statistical analyses of cacao experiments and their study by a biometrician.

The recommendations of the three Conferences on Plant Introduction and Quarantine Measures constitute a general guide, and have been highly valuable.

The remaining recommendations of the previous Conferences concerned general recommendations for research and on extension methods in cacao producing countries, and did not call for specific action by the Cacao Center.

The Conference decided to appoint the three sub-committees mentioned in the Introduction to these Proceedings to formulate specific recommendations on and to consider other recommendations as the need for them arose as the Conference progressed.

PAPERS PRESENTED

Summaries only of certain papers are given. Copies of the complete papers may be obtained on application to the Inter-American Cacao Center, Inter-American Institute of Agricultural Sciences, Turrialba, Costa Rica.

A brief summary of the discussions on the papers is included, based mainly on notes submitted by the participants in the discussion. It has not in general been possible to check the text of the discussions with the participants.

PAPER ON REHABILITATION

REHABILITATION FOR THE FUTURE

L.L. de Verteuil,* E.R. Moll**

INTRODUCTION

The Cocoa Subsidy Scheme, administered by the Cocoa Board of Trinidad and Tobago, has been in operation some fifteen years. The primary object of this Scheme is the replanting of cocoa on the suitable soils with plant material of higher yielding selections. At the onset of plant distribution in 1945 growers in Trinidad did not wholeheartedly accept the benefits offered. There were only 66 participants (as compared with an estimated 12-15,000 cocoa properties) and plantings were on a small scale.

With the continued high bearing of the oldest clones (planted on San Juan Estate in 1934) and the impressive performance of the early plantings, coupled with a long term favourable market outlook, proprietors gradually joined the Scheme; this is shown below:

Table I - Participants in Cocoa Subsidy Scheme
1945 - 1949

	Area Class (Total Acreage properties) in acres						
	0-10	11-20	21-50	51-100	101-200	201 +	Total
1945	10	7	10	6	10	23	66
1946	9	11	10	6	6	3	45
1947	23	17	27	13	10	23	113
1948	49	48	49	12	7	8	173
1949	166	115	77	32	23	46	459
1950	260	144	81	33	19	22	559
1951	291	129	98	26	18	18	580
1952	333	110	43	27	9	10	532
1953	342	130	85	18	10	13	598
1954	625	198	118	39	15	18	1013
1955	339	95	41	19	15	7	516
1956	404	132	53	19	10	8	626
1957	484	80	44	4	2	1	615
1958	763	199	95	12	6	1	1076
1959	605	158	62	6	-	-	831
Total	4703	1573	893	272	160	201	7802

* Chairman, Cocoa Board, Trinidad & Tobago

** Chief Rehabilitation Officer, Cocoa Board, Trinidad & Tobago

The increase in participation has led to increased demands for plant material and propagating facilities were expanded to the present annual production of 1-1/3 million plants.

REHABILITATION PROGRAMME

The replanting of cocoa in Trinidad under the Cocoa Subsidy Scheme is based on the grower receiving free plant material and a cash grant to help defray the heavy expenditure involved. Table II shows plant distribution annually with approximate acreages planted.

Table II Cocoa Rehabilitation - Trinidad and Tobago

Year	No. of Plants issued	Approx. Acreage Planted	
		Complete Replanting	Partial Replanting
1945	86,984	175	
1946	61,207	206	
1947	106,396	212	
1948	97,712	194	
1949	118,270	236	
1950	214,543	419	
1951	310,336	905	100
1952	300,095	642	950
1953	400,709	488	1,457
1954	484,094	605	1,852
1955	654,219	718	3,099
1956	1,040,693	1,481	3,670
1957	1,186,354	1,653	3,866
1958	1,282,181	1,933	4,009
1959	1,435,995	1,790	1,850
Total	7,779,788	11,657	20,853

During 1945-1950 plantings were only allowed on the basis of the complete replanting of old seedling cocoa; close planting (generally 9' x 9') without overhead shade was utilised extensively. These plantings were generally made by the larger growers who selected good lands. During establishment growth was good and high early bearing was achieved. With the removal of the temporary establishment shade and as the trees began to compete with each other,

high yields were not maintained; much criticism of clonal plantings resulted.

From 1951 the regulations controlling planting were drastically changed; clonal plants were only issued to growers whose preparation was made with overhead shade and with a minimum planting distance of ten feet square. Growers were advised to accept the traditional spacing of twelve feet square. Much of the early close plantings have subsequently had overhead shade planted and the cocoa thinned out. These areas are in general now giving high returns. As in illustration are the yield records of the Zephrine Field (planted 1945) on the Tortuga Estate, Montserrat.

Table III. Cocoa yield (lbs. dry cocoa), Zephrine Field (10 acres) Tortuga Estate, Montserrat, planted 1945.

Year	No. of Trees	Field Yield	Yield/Acre	
1945/47	5396	nil	nil	Establishment spaced 9' x 9'
1948/49	5396	1260	126 lbs	
1949/50	5396	4305	430 lbs	
1950/51	5396	9450	945 lbs	
1951/52	5396	6300	630 lbs	- Overhead shade planted
1952/53	5396	4410	441 lbs	- Thinned out on diagonal to approx. 13' x 13'
1953/54	2698	7539	754 lbs	
1954/55	2698	9632	963 lbs	
1955/56	2698	12521	1252 lbs	
1956/57	2698	12089	1209 lbs	
1957/58	2698	10214	1021 lbs	- Climatic variations
1958/59	2698	12837	1284 lbs	

During the early years smaller growers were loath to cut out existing cocoa fields for replanting in clonal cocoa. In the main those participating concentrated on the planting of alternative crops on lands no longer producing cocoa. Acreages of crops planted are shown below:-

Table IV. Approximate acreages planted in other crops

Year	Citrus	Coffee	Coconuts	Other Fruit	Pasture & Fodder
	Acres	Acres	Acres	Acres	Acres
1947	137	-	-	-	5
1948	135	-	2	2	41
1949	281	19	30	15	52
1950	276	66	34	14	32
1951	127	136	30	5	33
1952	165	232	30	-	31
1953	137	273	6	4	6
1954	132	297	4	-	9
1955	60	516	-	11	5
1956	19	204	-	18	1
1957	62	184	-	13	3
Total	1531	1927	136	82	218

In 1950 the planting regulations were changed to permit the partial replanting of old seedling fields. It was realised that on average the existing cocoa fields contained 20-30% of missing or non-productive trees and it was considered that in replanting a minimum of 35% of the area the effects of competition would be minimised. The partial replanting method was quickly adopted, in particular by the smaller growers, resulting in greatly increased demand for plant material.

RETROSPECT AND PROSPECT

At first glance it appears that there has been little increase in the annual cocoa production of the territory resultant from the 7.7 million plants issued in the Cocoa Subsidy Scheme. Average annual production over the past five years was 17,661,373 lbs as compared with 17,785,441 lbs for the preceding five years. However, it must be appreciated that some 5 million plants are still in the establishment phase and not yet in bearing. A realistic estimate of the effect of new plantings on the territory's cocoa production may be obtained by considering the acreage replanted or rehabilitated prior to 1955; this is 4,082 acres of complete replanting and 4,059 acres land partially rehabilitated (35% or more).

It is estimated that these plantings are yielding per acre on average 400 lbs. cocoa in the fifth year, 500 lbs. dry cocoa in the sixth year and 600 lbs. cocoa in the seventh and subsequent years. In addition, the acreage partially replanted is estimated to give an increased production of 200 lbs. cocoa per acre from the fifth and subsequent years. On this basis it is possible to estimate the annual production from new plantings; this is shown in Table V.

It must be realised that in the future production from the old seedling population will show diminishing returns. It is estimated that the present crop potential is in the region of 20 million pounds per annum, of which yields from new plantings account for 20%. This in effect means that without a Cocoa Subsidy Scheme the actual production would not exceed 15 million pounds and the industry in Trinidad would be faced with a steadily declining production. However, as a result of the active rehabilitation programme, the cocoa industry can look forward to steadily increasing returns. A forecast of this increase can be made on the estimated production shown in Table V this data is set out in diagramatic form in Figure I. From this it will be seen that anticipated production in ten years (1970) will be in the region of thirty-five million pounds per annum. Further, if the present rate of rehabilitating is sustained, a recurring annual increase of ¾ million pounds cocoa can be expected beyond this point.

The estimated yields in assessing production are based on the field performance of the earlier selections. Greatly improved plant material in the form of hybrid seed and new clones, has now become available. Therefore when plantings from this material come into production, it is anticipated that the actual yield will exceed the forecast.

Fig. I COCOA PRODUCTION - TRINIDAD & TOBAGO

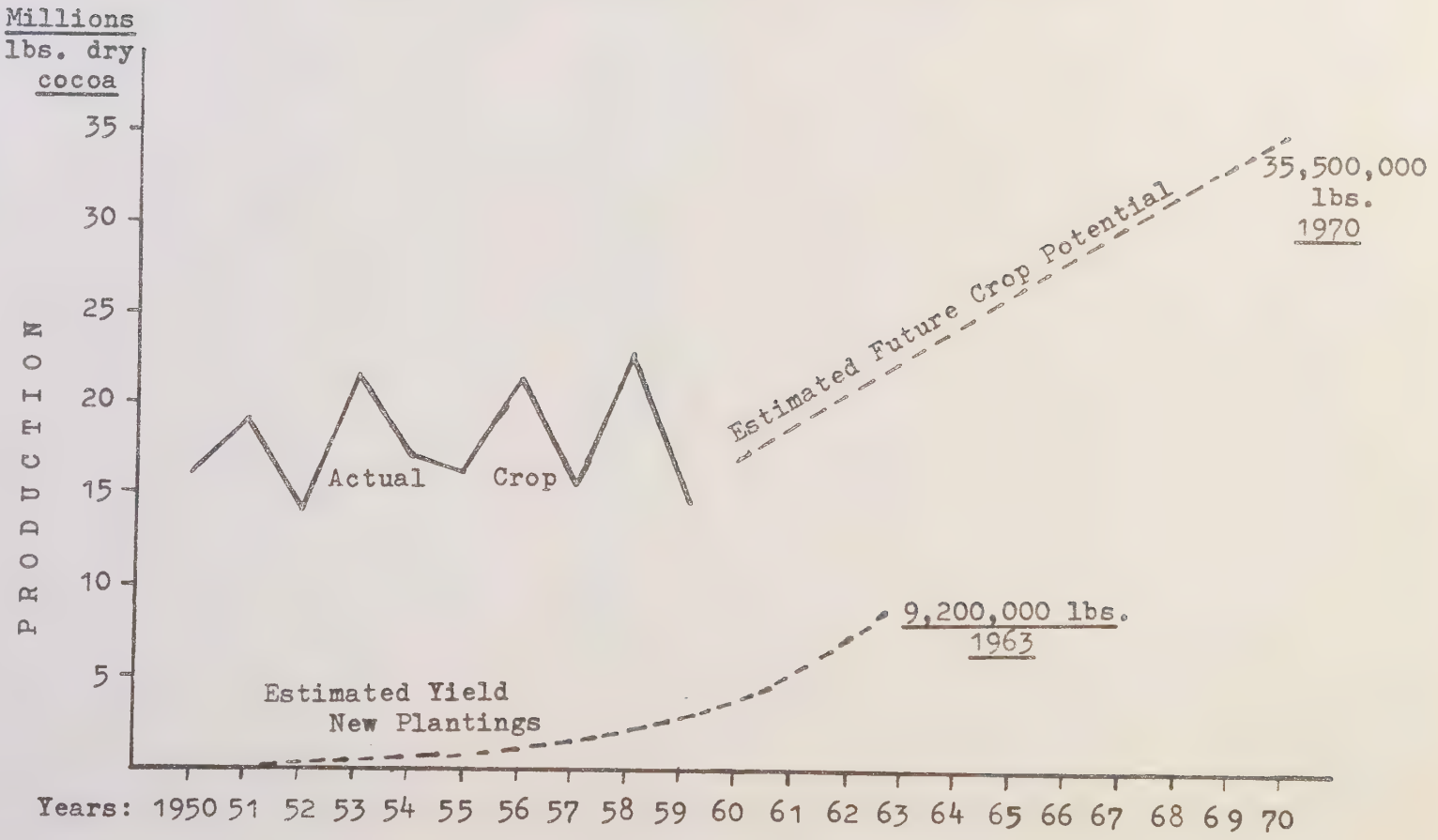

Table V. Estimated production new plantings. Yield in 1000 lbs. dry cocoa

1959	1958	1957	1956	1955	1954	1953	1952	1951	1950	Acreage Planted C.R.	P.R.	
907										605	1852	1954
672.9	612.4									488	1457	1953
572.5	511	446.8								642	950	1952
563	563	472.5	382							905	100	1951
251.4	251.4	251.4	209.5	167.6						419	-	1950
141.6	141.6	141.6	141.6	118	94.4					236	-	1949
116.4	116.4	116.4	116.4	116.4	97	77.6				194	-	1948
127.2	127.2	127.2	127.2	127.2	127.2	106	84.8			212	-	1947
123.6	123.6	123.6	123.6	123.6	123.6	123.6	103	82.4		206	-	1946
105	105	105	105	105	105	105	105	87.5	70	175	-	1945
3580.6	2425.8	1784.5	1205.3	757.8	547.2	412.2	292.8	169.9	70	Total Prod.		
15885.4	18179.2	15945.7	21836.7	16459.7	17640.8	21684.5	14087.4	19316.6	16197.9	Actual Crop		
20%	13%	11%	5½%	4%	3%	2%	2%	.75%	.5%	Estimated proportion		

SUMMARY

The Cocoa Subsidy Scheme in Trinidad is described. When the Scheme began in 1945, there were only 66 participants, but in 1959 there were 7802. This has caused a considerable increase in the demand for plants, and the present annual production is about 1-1/3 million plants. Some 7.7 million plants have been distributed, representing the rehabilitation of 30,000 acres of cacao.

At first only complete replanting was allowed, and close spacing without shade was advised. As experience was gained, shade and wider spacing was advised, and partial replanting was allowed. The grower receives free plants and a cash grant to help defray the cost of replanting.

It is estimated that 20% of the present crop potential of 20 million pounds a year comes from new plantings. Production by 1970 is estimated at 35 million pounds a year.

RESUMEN

Se describe el Programa de Subsidios de Cacao en Trinidad. Cuando comenzó el programa en 1945, habían solo 66 participantes, pero en 1959 alcanzó el número de 831. Esto ha ocasionado un aumento considerable en la demanda de plantas, y al presente la producción anual es de más o menos un millón y 1/3 de plantas.

Se ha distribuído unos 7.7 millones de plantas, o sea unos 30,000 acres de cacao rehabilitado.

Al principio solamente se permitió replantaciones completas y se aconsejaba siembras a distancias cortas sin sombra. Conforme se gano experiencia, se aconsejó usar sombra y mayores distancias y se permitió replantaciones parciales. El sembrador recibe plantas y un subsidio de dinero en efectivo para ayudarle a mantener el costo de la replantación.

Se estima que 20% de la producción potencial actual de 20 millones de libras por año proviene de plantaciones nuevas. Se calcula que para 1970 la producción se elevará a 35 millones de libras por año.

SUMMARY OF DISCUSSION

Sr. M. Aspiazu (Ecuador)

I will summarise our rehabilitation work in Ecuador. In 1943 Professor Cheesman of the ICTA outlined a general plan for rehabilitating our cocoa industry. In 1948, thanks to the cooperation of the Trinidad Agricultural Department, we obtained clonal material with which to commence our work. The first plantings of clonal material were at Hacienda Clementina in 1948, and the testing and selection of new material has been carried out at the Pichilingue Experiment Station. To date some 6,000 hectares of clonal cacao have been planted in Ecuador. Of these 3,400 hectares were planted in 1958. Our planting programme since 1958 has been affected by lack of credit throughout the country. Further, our banana industry is booming; in Ecuador we are now the first banana producer in the world, last year supplying 51 per cent. of the needs of the American consumer, representing 36 million stems of bananas. The increase in bananas has been largely near cacao areas, which has helped us in reducing the cost of establishment in our replanting programme. However, it has had the effect that many cacao producers have appreciated that better returns may come from banana production and, as a result, have eased off in the rehabilitation of cacao. Recently our growers have become interested in the use of hybrid seed and we hope that in the future there will be increased plantings using this material. We plan that as Panama disease infests bananas now grown on our good old cacao lands, that we will be able to switch these areas back into cacao production.

Mr. A.F. McKenzie (West Indies)

In many of the northern West Indian Islands, the recent remarkable increase in banana production has had a serious effect on our cacao planting programmes. However, we feel that in taking a long-term view, much of this land will come into cacao production. Growers in these islands, through profits from banana production, are able to offset greatly the heavy cost of establishing cacao plantations. I consider that in our rehabilitation programmes insufficient attention is being paid to soil conditions in areas being replanted and also, not enough work is being aimed at improvement in levels of management through proper training programmes.

Mr. B.F. Topper (Jamaica)

Mr. McKenzie's remarks on bananas refer to the smaller islands. In Jamaica our banana industry is on the decline and we have no trouble in getting people to plant cacao. Our programme in Jamaica aims at increasing our present acreage of 12,000 to 60,000 acres within the next ten years. I consider that the traditional planting of cacao in the middle of the banana rows is wrong and that if the cacao is planted close to the banana stool much of the ill effects of drought can be minimised. With reference to Mr. Moll's paper, I should like further information on the quality of cacao produced from hybrid seedlings.

Mr. Moll (Trinidad and Tobago)

With regard to flavour in hybrid seedlings, our assessments to date have been from the early plantings made at Marper in 1950. These were fermented and dried on a commercial scale and samples sent to manufacturers in the United Kingdom and North America. These samples were identified as giving typical Trinidad flavour. I think that in part this may be due to the fact that the Scavina are tied up with the flavour cacao in Ecuador.

Mr. Havord (IAIAS)

I should like to add to what Mr. McKenzie has said about the importance of soil environment and the success that can be expected by rehabilitating. In old plantations the worst cacao fields are generally in the areas with the worst soil and these are the first to be rehabilitated, so that much of the replanting with new material does not give as good returns as is expected. It is probably self-evident that perhaps far better returns could be obtained if the valuable new high-yielding varieties were concentrated in the better areas, even though it may mean removing some of the better old cacao. I wonder whether Mr. Moll would be prepared to express an opinion on the relative merits of clonal material and hybrid seedling material.

Mr. Moll (Trinidad and Tobago)

The policy of the Trinidad Cocoa Board is at present to give out a mixture of both hybrid seedlings and clonal cuttings. This year the proportion will be 40 per cent. seedlings and 60 per cent cuttings. We consider that the hybrid seedling material at present available is comparable to our better clones already in use. I consider that this is particularly the case where partial

replanting is the practice, in that hybrid seedling material is more vigorous and will withstand better the competition amongst the older seedlings. With regard to the future, we still consider that it is possible to get the best results with clonal plants, particularly the new selections that are now becoming available, providing that they are planted under good conditions of environment and given good management.

Mr. Quartey-Papafio (Ghana)

In Ghana our main problem is the rehabilitation of areas with Swollen Shoot. Our Government's assistance is at the rate of £20 per acre for cutting out Swollen Shoot in infected areas, with a further subsidy of £30 per acre for replanting. Plant material is issued at subsidised prices, pods are sold at 10/- per 100 and seedlings sold at 1d to 3d each. At present our average farmer produces about 200 lbs. dried cocoa per acre per annum and we have something like 3½ million acres of cocoa in production. Seed material from Amazonian varieties obtained through WACRI give considerably better yields; in trial plots at Bunso planted at 10' x 10' yields are over 2,000 lbs. per acre. This important planting material will soon be available for issue to farmers.

Sr. Trujillo (Venezuela)

In general we are faced with cacao plantations that are now depleted, having been established some 60-100 years ago. These plantations were made at a time when the labour investment was a small factor. I am of the opinion that no cacao grower can cut down all the trees that are giving him his means of livelihood, so that some time in the future he may obtain improved yields. He would have no means of livelihood in the meantime. Because of this in Venezuela we have a great deal of trouble in trying to introduce better plant material to our farmers. I consider that the first thing we should try to achieve, and I should like to present a formal proposal to this technical group, is that we should address ourselves to the FAO Cocoa Study Group concerning the stability of prices, so that we can look forward to a future in which profits are possible. With this future in mind it would be easier to continue the expensive cost of rehabilitation.

Mr. Akinwolemiwa (Nigeria)

In Nigeria our problem is similar to that stated by my friend from Ghana. Recently we have suffered from Swollen Shoot, though fortunately a less virulent strain than that of Ghana. Our policy

is to cut out infected trees and, where the disease is widespread, to seal off the area of infection. In most cases our farmer has no alternative cash crop, so therefore our Government provides compensation for each tree cut out, and encourages the replanting of cacao or the establishment of an alternative crop, such as citrus. Most of our farmers prefer to replant with cacao but this is not always easy as many of our existing areas are marginal for continued cacao cultivation. We do have in our country land that is much more suitable for cacao cultivation and we hope, with the better material, mainly from Amazonian varieties made available through WACRI, that in the future we would be able to plant on these better lands. In Nigeria there are just over one million acres of cocoa with an average yield of about 240 lbs. dry cocoa per annum. We have found that where farmers have sprayed against pests in the cacao, the effects of Swollen Shoot are less, and recently we have concentrated our efforts on this work. I would like to ask Mr. Moll how his Government has been able to persuade farmers to cut out and replant cacao as this is a serious problem in Nigeria.

Mr. Moll (Trinidad and Tobago)

This was the main problem when the subsidy programme commenced. However, fortunately in Trinidad there are larger growers who, since the scheme commenced, have followed an active policy of cutting out and replanting with new selections. These plantings have been a wonderful example to the smaller growers who have tended to follow the work being carried out by the larger growers. The partial replanting system of rehabilitation was adopted principally because of the small farmer.

Dr. Tinsley (Nigeria)

I should like to add to what my colleague from Nigeria has said about pest control. We have found that by spraying areas of cacao in poor condition and controlling capsid, we can increase the yield per acre from under 100 lbs. per annum to 900 lbs. per annum. This only applies in areas with a degree of infection of Swollen Shoot as such that no cutting out is done. We consider that there is little use in trying to persuade farmers to replant cacao when every day they are seeing the ravages of pests in the old cacao. By giving a subsidy to buy insecticides and spraying equipment, and training the farmer how to control capsid, he can obtain on his own farm better returns. He then is in a more receptive frame of mind to think in terms of increased returns by replanting.

Mr. Van Suchtelen (Surinam)

Rehabilitation of our cacao industry utilising clonal material from Trinidad commenced in 1948. At that time we had considerable difficulty in persuading growers who were used to seedling trees to plant clonal cuttings. However, when some cuttings were established and good results achieved, our growers took seeds from the cuttings and obtained very poor results. The result is now that it is very difficult to persuade these growers to utilise seedling material.

Mr. Moll (Trinidad and Tobago)

In Trinidad very little planting was done with seed from clones. At present we base our scheme on actually providing the grower with plant material rather than seeds, so that we have control over the type of material that is being planted.

Mr. Havord (IAIAS)

Mr. Moll has described the Trinidad policy with regard to the use of cuttings and hybrid seed. In Trinidad propagating facilities on a large scale already exist, but in most of Latin America, where there is a desire to increase greatly plantings of cacao, these facilities do not exist. Today, with hybrid seedlings, it is possible for these areas to carry out extensive replanting using improved material at a lower cost than would be required to produce cuttings, and, more important, the number of seedling plants that can be produced is much greater, so that considerably faster progress can be made than would be the case with cuttings.

PAPERS ON FERMENTATION AND DRYING, BIOCHEMISTRY

THE SIGNIFICANCE OF CURRENT RESEARCH ON CACAO FERMENTATION

L. A. Griffiths *

Much of the current research on cacao fermentation is of a highly technical nature, the significance of which is not immediately evident to the layman. It is therefore proposed to make a brief survey of the aims and objectives of current research in this field.

Although physical criteria such as colour, plumpness and "break" are frequently the basis of quality assessment in commercial circles, the final criterion of quality in cacao is flavour. Not only is the intensity of chocolate flavour of the bean of importance but also the auxiliary flavours which give beans from different geographical areas their characteristic flavour properties. The desire of the manufacturer in short is for beans showing the strongest possible chocolate flavour together with those flavour characteristics which are traditionally associated with the region.

Recently much criticism has been voiced by the U.K. buyers of the flavour quality of West Indian cacao. It is alleged that the flavour and quality is highly variable and that in general there has been an appreciable decline in quality over the past twenty years.

This state of affairs must be a matter of great concern to local growers since the premium that their product commands rests on the maintenance of these desirable flavour characteristics. Failure to maintain the characteristic flavour quality of say, Trinidad cacao will result in loss of the premium as the manufacturer will not be prepared to pay higher prices for a product, which is not markedly different in flavour to the bulk cacaos.

Much of the variation in flavour quality that we have noted

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* Regional Research Centre, Imperial College of Tropical Agriculture, Trinidad.

would be expected from a consideration of the techniques of fermentation at present employed in the growing countries. The course of cacao fermentation is determined very largely by the nature of the micro-organisms occurring in the individual sweat box and by the physical and chemical factors which govern their proliferation and metabolic activity. Although careful supervision of curing does considerably increase the likelihood of obtaining a good quality cacao, even under conditions of good management variability in the product cannot be eliminated. In talks with a representative of the U.K. firm of Rowntrees, this variable character of Trinidad cacao was stressed and we were informed that even cocoa from one of the best estates in the island, where every care is taken in preparation showed a marked variation in flavour quality between batches. This situation underlies the need for a considerable increase in the volume of bio-chemical and technological research upon the factors determining chocolate flavour as it will be only when a complete understanding of the complex changes occurring in cacao fermentation is obtained that measures can be taken to ensure that uniformly high quality cacao is produced.

Apart however from ensuring uniformity of flavour quality it is desirable that research should also be carried out into the possibility of producing stronger chocolate flavour by modification of the traditional techniques, for not only are the estate methods subject to the variation that we have noted but in addition there is reason to suppose that stronger chocolate flavours could be induced by suitable modification of the technique. The point to bear in mind is that the chemical conditions under which cacao is routinely cured are to a large extent accidental and are determined by the nature of the microflora and by the prevailing physical and chemical conditions which may limit their proliferation and metabolic activity. In the course of fermentation the multiplication of these organisms is promoted by certain factors e.g. high sugar concentration, degree of aeration and inhibited by other factors e.g. high temperatures and low pH. The rate of development of the microflora will therefore depend very largely on the nature of the pulp and also upon the ecological characteristics of the organisms themselves. The production of heat and acetic acid, the importance of which for cacao curing has been emphasized by recent research, will then very largely depend upon the survival of the appropriate organisms under conditions of extreme environmental complexity. It is evident that there is no reason whatsoever to suppose that the resulting chemical milieu, determined almost wholly by the microflora, is that which is optimal for flavour development in cacao. This underlines the need for establishing in clear

scientific terms the nature of the chemical changes which occur in the bean during fermentation and of the factors which determine the rate at which these changes occur.

Although considerable progress in the study of the chemical constituents of the bean has been made during the past ten years, the significance of these researches will only be fully apparent when the actual chemical mechanism of chocolate flavour formation is established.

The polyphenols of cacao including flavonoids and phenolic acids have received intensive study, (Forsyth 1955, Forsyth and Quesnel 1957, Griffiths, 1958, 1960a) as there is little doubt that these substances are of considerable importance in determining bean flavour. However there is a strong possibility that other chemical substances in the bean may also play an important part in chocolate flavour and current research is actively concerned with these possibilities.

The basic problem of fermentation research is undoubtedly to establish the chemical mechanism by which the latent property of chocolate flavour is induced in the bean. It is common knowledge that unfermented beans on roasting give a product that is completely lacking in chocolate flavour and aroma. Our knowledge of the chemical steps involved in this process is however extremely slight. Solution of this problem is moreover of considerably more than academic interest as an understanding of the nature of the chemical changes occurring will enable us to devise improved methods of cacao curing. It is most desirable therefore that fundamental research on the constituents of the bean is not neglected as a knowledge of cacao bean chemistry is basic to a study of this problem.

As a result of chromatographic studies during the past ten years the major polyphenolic constituents of the cacao bean have been separated and identified. The purple pigments α -L-arabinosidyl cyanidin and β galactosidyl cyanidin, compounds of the catechin group in which l-epi-catechin predominates, and the leuco-anthocyanidins have been studied in some detail (Forsyth 1955, Forsyth and Quesnel 1957, Griffiths 1960a). Knowledge of the minor polyphenolic constituents is however more limited although evidence for the presence of certain phenolic acids and flavonols has recently been presented (Griffiths, 1958). The significance of these compounds in relation to cacao technology is of some interest. Firstly the purple pigments, the anthocyanins, have always been associated by the trade with under-fermentation; under-fermented beans being characterized by a purple colouration attributable to residual anthocyanin.

That the astringent flavour of such beans is not however to be attributed directly to these compounds was recently established when chromatographically pure solutions of cacao anthocyanins were tasted and found to be almost lacking in any definable flavour. On the other hand l-epi-catechin possesses extremely harsh and astringent flavour properties and there is little doubt that if the epicatechin content of a bean is high the dominant flavour will be of marked astringency. It was earlier shown (Griffiths, 1957) that epicatechin is the major substrate of cacao bean polyphenoloxidase and if this reaction is allowed to proceed to completion during the drying stage the beans should be completely freefrom undesirable astringency. It has been suggested by Quesnel (1957) that the chocolate aroma principle is a phenolic glycoside, which during fermentation is hydrolysed by a glycosidase system forming a substance which on roasting gives the characteristic aroma of chocolate. Intensive chromatographic studies at I.C.T.A. have not however indicated any substance, which can be identified with properties of this type. Employing paper chromatography, it is possible to obtain a complete resolution of the phenolic constituents of a methanolic-HCl extract and examination of such chromatograms, using a wide range of spray reagents did not reveal any uncharacterized spots which could be equated with a compound of this type.

The possibility that the active substance is present in such small quantities that it escapes detection is not in our opinion likely in view of the great sensitivity of these methods. A possibility which should however be borne in mind is that the aroma precursor is a non-hydroxylated, benzenoid derivative. Such a compound would of course not be detected by the phenolic reagents routinely employed. It appears however desirable that at this stage no assumptions be made as to the nature of the aroma compound but that the results of current research on the fractionation of the bean constituents be awaited.

In addition to fundamental studies on the flavour principles of the cacao bean, considerable attention has been given at I.C.T.A. to the study of the physical and chemical factors determining the course of cacao fermentation. The object of these studies is to establish the best possible conditions for the preparation of high quality cacao. Our approach to the problem has been based upon the use of a small-scale laboratory method designed to simulate as closely as possible the conditions obtaining in the typical sweat box. The results of these experiments were recently published. (Griffiths, 1960b). As a result of these and parallel investigation on large-scale fermentation (Howat et al, 1957, Rohan, 1958, Bridgeland, 1960)

and aseptic fermentations (Quesnel, 1957) a considerable, although by no means complete understanding, has now been obtained of the more basic changes occurring during fermentation. It should moreover be noted that although there is a large measure of agreement between different research workers on the more basic changes occurring during curing, there are still a number of points upon which opinion is conflicting.

The state of knowledge in the subject is moreover complicated by much speculative writing on cocoa fermentation. Before giving some account of our view of fermentation, it should be stressed therefore that this interpretation rests either upon experimental work done at I.C.T.A. or upon our experimental confirmation of observations made elsewhere.

In our view, the essence of the fermentation process is the establishment of an optimal acetic acid/temperature relationship in the fermenting mass. When the critical requirements are met, cell lysis occurs resulting in the liberation of enzymes and substrates under conditions favourable to their interaction. In the event of sub-optimal acetic acid formation, lysis is incomplete and the beans possess a weak chocolate flavour and high astringency. When the acetic acid level is too high a similar harsh flavour character results. Although the final result in both cases is the same, the mechanism in each is very different. In the former case high astringency and the absence of marked chocolate flavour are to be attributed to a failure of the enzymes, including the glycosidase and polyphenoloxidase systems and the substrate to interact due to the cells not being sufficiently disrupted. The astringency is readily accounted for as it is possible to extract large amounts of unoxidized epicatechin from such beans even after long exposure on the drying floor.

On the other hand beans in which the acetic acid level is in excess of the optimum undergo rapid cell lysis with an equally rapid release of cell enzymes. However the activity of the enzymes under these conditions viz. high pH is considerably reduced. This results in retardation of enzymic activity and the eventual denaturation of most of the enzymes present. Under these conditions, formation of the chocolate flavour precursor is reduced or suppressed and the polyphenoloxidase system is inactivated, resulting in high astringency due to large residual amounts of unoxidized epicatechin.

In these changes temperature has been shown to act synergistically in relation to acetic acid, the result of sub-optimal or excessive temperature resembling that of sub-optimal

or excessive acetic acid concentration.

A topic upon which there has been much conflict of opinion is whether the earlier stages of fermentation are essentially anaerobic or whether limited aeration of the cotyledon is beneficial. This question was studied earlier at I.C.T.A. and our findings have recently been published (Griffiths, 1960b). Our general conclusion was that the evidence is strongly in support of the view earlier put forward by Forsyth that these changes are essentially anaerobic in nature. In our experiments it was found that when the oxygen tension of the cotyledon was increased above the normal level, a marked decrease in flavour resulted. It is important however to stress that this issue is of course separate from the question of the degree of aeration, which is optimal for the development of the microflora of the pulp. Providing that the natural barriers to the ingress of oxygen into the cotyledon are operative (Griffiths, 1960b) the only requirements which need be considered for the aeration of the pulp are those relating to the development of the Acetobacter which are responsible for the establishment of optimal acetic acid levels.

It has recently been suggested by Bridgeland, (1960) that prolongation of fermentation beyond three days is to enable oxidative changes to occur in the cotyledon. This however is completely contrary to our experience in Trinidad. It is undoubtedly true that beans removed at the end of three days from an estate sweat box are harsher in flavour than those which have received up to eight days fermentation. In our opinion however, the need for the extended period of fermentation is not for the oxidative changes to occur in the box but rather for the process of cell lysis to proceed sufficiently far, (and this is an anaerobic process), for the polyphenoloxidase enzymes to be released in sufficient amounts to oxidise the residual polyphenols later during exposure on the drying floor.

The changes occurring in the cotyledon during curing may be considered as falling into three separate phases:

Fermentary		Drying Floor
Anaerobic lytic phase	Anaerobic enzymic phase	Aerobic enzymic phase
Induced by acetic acid formation and higher temperatures	Insolubilization of leuco anthocyanidins; peptidase activity; anthocyanin breakdown	Conversion of epicatechin to brown polymerization products; other oxidation enzymic reactions.

Considerable attention has in the past been given to the changes undergone by the anthocyanins in fermentation. Forsyth has in fact described the earlier phase of fermentation as an anaerobic hydrolytic phase, as it is characterized by hydrolysis of the anthocyanins. It is however important to recognize that far from being the most important event during early fermentation, the available evidence suggests that these hydrolytic changes are of very secondary importance. The suggestion moreover of Bridgeland (1960) that the chocolate flavour precursor is formed by hydrolytic and oxidative action on the anthocyanins is completely without suport, indeed the existence of unpigmented Criollo cacao possessing normal chocolate flavour is in itself sufficient to contradict the suggestion that latent chocolate flavour can be equated with the presence of anthocyanins.

It must be recognized that whilst the hydrolysis of anthocyanin is a useful index of fermentation, as it reflects the enzymic changes following the lytic release of cell enzymes, there is at present no evidence to suggest that the cacao anthocyanins are in any way connected with the process of flavour development in the bean.

This of course brings us back to the main and outstanding problem of cacao fermentation research namely the identity of the chocolate flavour principle and the nature of the chemical changes resulting in its formation. Future research must make an intensive effort to provide an answer to this problem, but in addition to this work parallel investigations are needed to ensure that a sufficient body of knowledge is obtained for the practical guidance of the planters and to ensure the maintenance of high standards in raw cacao production.

SUMMARY

Auxiliary flavours which give beans from different areas their flavour characteristics are important. It has been alleged that the flavour and quality of West Indian cacao is highly variable and has declined in the past twenty years. More biochemical and technological research on the factors determining chocolate flavour and on how to produce stronger chocolate flavour is therefore needed.

The reasons for the variability encountered are discussed, and our knowledge of the chemical constituents of the bean is reviewed. Astringency is now believed to be due to l-epi-catechin, not to the purple anthocyanin pigments as formerly supposed. Chromatographic studies have failed to confirm Quesnel's hypothesis that the chocolate flavour principle is a plerolic glycoside.

Small scale fermentation techniques have led to a more complete understanding of the changes occurring during fermentation. The essence of the process is the establishment of an optimal acetic acid/temperature relationship resulting in cell lysis and the liberation of enzymes and flavour substrates. Departure from the optimal relationship results in high astringency and lack of chocolate flavour, and the reasons for this are discussed.

The author's experiments support the view that the earlier stages of fermentation are anaerobic. The changes in the bean fall into three phases: the anaerobic lytic phase and the anaerobic enzymic phase during fermentation, followed by an aerobic enzymic phase during drying.

RESUMEN

Se menciona la importancia de ciertos sabores complementarios, que dan el sabor característico a las almendras de cacao de areas diferentes. Se ha dicho que el sabor y la calidad del cacao de las Indias Occidentales son altamente variables y que han declinado en los últimos veinte años. Se necesita, por tanto, más investigación técnica y bioquímica sobre los factores que determinan el sabor de chocolate y sobre cómo producir un sabor de chocolate más fuerte. Se discute las razones para la variabilidad encontrada y se revisa el actual conocimiento de los constituyentes químicos de las almendras. Se cree que la astringencia se debe a l-epicatequina, no a los pigmentos púrpuras de antocianinas, como antes se creía. Estudios cromatográficos no han confirmado la hipótesis de Quesnel que el principio del sabor a chocolate es un glucósido polifenólico.

Las técnicas de fermentacion en pequeña escala han colaborado a un entendimiento más completo de los cambios que se suceden durante la fermentación. La esencia del proceso reside en el establecimiento de una relación óptima temperatura/ácido acético que da como resultado la lisis de las células y la liberación de enzimas y sustratos de sabor. El alejamiento de las relaciones óptimas da como resultado gran astringencia o falta de sabor a chocolate y se discuten tambien las razones para estos resultados.

Los experimentos del autor apoyan la teoría que los primeros estados de la fermentación son anaeróbicos. Los cambios en las almendras se dividen en tres grupos: la fase anaeróbica lítica y la fase anaeróbica enzimática durante la fermentación, seguida por una fase aeróbica enzimática durante el secado.

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THE ENZYMATIC TRANSFORMATIONS WITHIN CACAO BEANS DURING THE FERMENTATION PROCESS*

Arnulf Purr, Rudolf Springer and Hartmut Morcinek**

As Forsyth (1) (2) and his collaborators have shown, in the fermentation process an interaction occurs between the polyphenols and the proteins, due partially or entirely to the action of polyphenol oxidase, an effect which favourably influences the formation of cacao flavour. There follows a diminution in the astringent substances because of the insolubility of the polyphenol-protein complexes formed, and thus the adverse flavour component otherwise developed by roasting will not show. The formation of peptido-polyphenols mentioned was confirmed by Schubiger, Roesch, and Egli (3) who, using paper chromatography, detected five substances which give Turnbull's blue (proof for polyphenols) and also are stained by "Amidoschwarz 10B" (specific for proteins). The authors did not consider the way in which these substances were formed.

The subject of our own experimental study had been the reactions between the primary products of the enzymatic oxidation of catechols and proteins, peptides, and amino acid components of cacao proteins. The results obtained were as follows:

1. The activity of polyphenol oxidase of ungerminated beans, as well as the augmentation of the rate of activity with progressing germination depends on the kind of beans under examination (fig. 1).

2. A moderate increase in oxygen uptake upon the addition of various amino acids or peptides to an experimental batch of polyphenol oxidase and catechol substrate, the addition made at the chinon formation level of enzymatic action.

3. Very strong increase of oxygen uptake upon addition of the same protein fission products as before (cf. pos. 2) or of Zeine, if the batch contains also L-proline. Same as measurements of fig. 1, exact values vary slightly with the kind of beans (fig. 2a - 2c).

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* Extract from an article, published in the March 1960 issue of "Zeitschrift fuer Lebensmittel-Untersuchung und - Forschung". (in press).

** Institut fuer Lebensmitteltechnologie und Verpackung, Muenchen, and Institut fuer Pharmazie und Lebensmittelchemie der Universität Muenchen.

4. Strongest increase of oxygen uptake as caused peptides with presence of glycyl-glycine in the batch. DL-leucyl-glycine does not cause any increase.

5. Various amino acid components of cacao protein contained in the batch as a factor of increase of oxygen uptake (cf. fig. 2a - 2c). By far the strongest effect is caused by glycine under various conditions. In order of decreasing effect follow DL-threenine, DL-serine, L-alamine and DL-lysine. No influence was obtained with D-arginine, L-glutamic acid, and L-leucine.

The results from our experiments show how the action of proteinase may couple with the oxidase-action during the course of the fermentation process. What will happen are reactions between the products deriving from the substrates, as, indeed, polyphenolprotein complexes have been found in the fermented bean material (3). In fact, the prerequisites of a reaction milieu in which the chemical reactions discussed will follow enzymatic breakdown are given in a normal cacao fermentation.

These coupled reactions, according to a scheme suggested in the literature (4), occur in the following stages:

$$\boxed{\text{Polyphenol}} + \boxed{\text{Amino Acid}} + 1/2\ O_2 \xrightarrow{\text{Polyphenol Oxidase}} \text{Adduct}$$

These adducts then act as catalysts for the oxidative deamination of amino acids

$$\boxed{\text{Amino Acid}} + 1/2\ O_2 \xrightarrow{\text{Adduct}} \boxed{\alpha\text{-keto Acid}} + \text{Ammonia}$$

$$\boxed{\alpha\text{-keto Acid}} \rightarrow \boxed{\text{Fruit Flavour Constituent}}$$

For instance, the deamination of threonine will, according to the reaction scheme, result in the formation of β-oxy-α-ketobutyric Acid, which is known as a flavour constituent in cranberries (5). Whether the reaction route as indicated is relevant for the formation of the "Flavour precursor" of the fermented and dried cacao bean still remains to be explored.

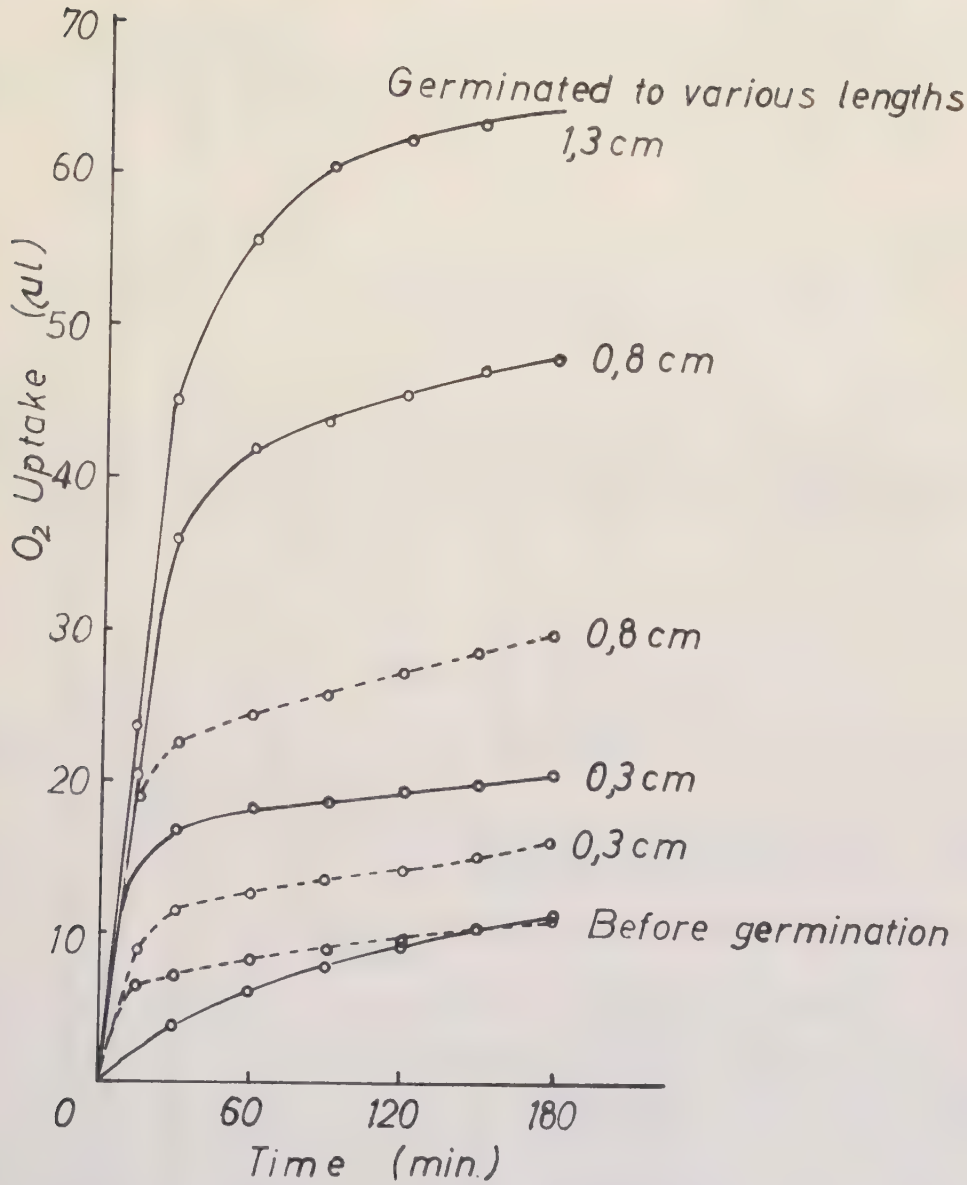
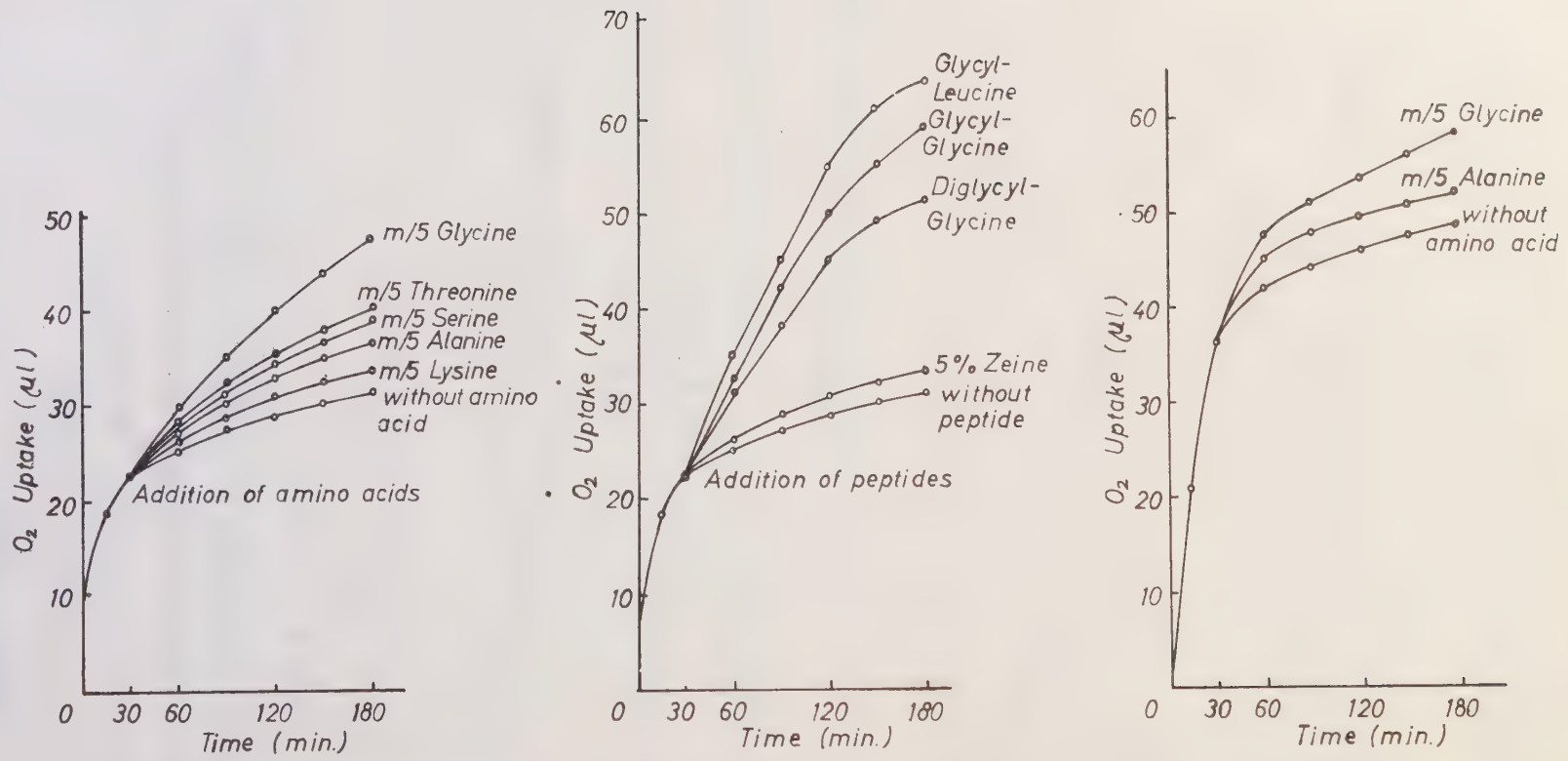


Fig.1. Enzymatic oxidation of catechol by polyphenol oxidase in beans before germination and germinated to various lengths.

o——o Costarica beans

o- - - -o Bahia beans.



a) Bahia beans with added amino acids

b) Bahia beans with added peptides and Zeine

c) Costarica beans with added amino acids

Fig.2. Consumption of oxygen in presence of L-proline after addition of amino acids or peptides to a polyphenol oxydase batch, 30 min. after preparing the batch. Extract. from beans germinated to a length of 0,8 cm.

SUMMARY

The author discusses coupled reactions between primary oxidation products, formed by enzymatic oxidation of catechol by action of polyphenol oxidase, and proteins, peptides and amino acid components of the cacao proteins.

RESUMEN

El autor discute las reacciones "coupled" entre los productos de oxidación primaria, formados por oxidación enzimática de catecol por acción de la oxidasa polifenólica, y las proteinas, los peptidos y los componentes aminoácidos de las proteinas del cacao.

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SUMMARY OF DISCUSSION

Dr. V.C. Quesnel (Trinidad)

I would agree with the general picture of cacao fermentation presented by Dr. Griffiths, for this seems to be essentially the same picture put together by Forsyth and co-workers. However I wish to make a number of comments on details.

I may amplify his remark that substances other than polyphenols may play a part in chocolate flavour by pointing out that it is now almost certain that linalool is the substance responsible for the distinctive rose flavour of Arriba cacao. The evidence is as follows: Bainbridge & Davies isolated linalool from Arriba cacao in 1912. Linalool is a constituent of several essential oils in trace amounts it smells of roses and in strong solutions of citronella or lemon. Linalool added to ICS 1 cacao during curing by my "aseptic" technique produced in the cacao a flavour described as "lemon and nutmeg". Obviously too much linalool had been added and I realised this even before sending samples for assessment. Linalool is not phenolic, occurs in the bean before fermentation and remains unchanged during fermentation.

As regards my suggestion that chocolate aroma precursors are produced by hydrolysis of phenolic glycosides, I repeat that this is only a hypothesis and I am quite willing to abandon it when the evidence shows it to be incorrect. So far this evidence is not available. On the contrary, we have found glucose and xylose, apart from the arabinose and galactose of the anthocyanins, in hydrolysates of polyphenolic fractions and they can come only from phenolic glycosides or polysaccharides which contaminate the polyphenols. Consequently the presence of phenolic glycosides, other than the 2 anthocyanins, cannot be discounted. I disagree with Dr. Griffiths that the methods he is using are sensitive enough to detect such compounds. I believe that they are present in such small amounts that they require concentration before they will become detectable.

In discussing the work of Bridgeland to which Dr. Griffiths refers I am at a disadvantage because I have not yet read Bridgeland's paper. However, Bridgeland's suggestion that important oxidation changes may occur in the later stages of fermentation cannot be dismissed out of hand. In Grenada last year I divided a sweat-box-full of beans into two at the end of 6 days fermentation, (when I thought that fermentation had lasted long enough), removing one portion to the drying floor and letting the other continue for the length of time which is normal on the estate viz. 10 days. At the end of that time the beans were almost black and

stank of rotten fish. Assessment of chocolate made from samples of these two lots of beans showed that the latter was far superior. There are two possible explanations: 1) That the same substances which cause the objectionable fishy smell enter the bean in minute amounts there giving rise to pleasant aromas in the same way that indole and skatole which cause the obnoxious smell of faeces are used in trace amounts in perfumes; 2) that an oxidation at high temperature such as the beans receive in the sweat-box is better than a low-temperature oxidation such as occurs on the drying floor. The second paper in this section proposed a mechanism whereby oxidation could lead to the production of aroma principles. I do not believe that the extra time of fermentation after 3 days is necessary for the release of polyphenol oxidase as Dr. Griffiths suggests. We have shown that from the second day on the amount of polyphenol oxidase in fermenting beans decreases rapidly until by the fifth or sixth day only about 2% of the original amount remains.

As regards Bridgeland's expressed opinion that "chocolate flavour precursor is formed by hydrolytic and oxidative action on the anthocyanins" (quoted from Griffiths' paper not Bridgeland's), it is not sufficient to quote the mere existence of Criollo cacao as conclusive evidence against this. Criollo cacao produces a special kind of chocolate with a flavour more akin to nuts than to a true chocolate flavour. We have in our file a letter from Vyle of Terry's which says that Venezuelan growers of Criollo cacao like to have their beans tinged with purple to put the chocolate flavour in. Those were his words "to put the chocolate flavour in". I leave you that to think about.

Let us face up to it; we do not know very much about chocolate flavour.

Mr. B. Topper (Jamaica)

With regard to the percentage of moulds present in the bean that affect the final flavour of chocolate produced, I understand that beans with moulds of less than 5 per cent. can produce mouldy flavour in the chocolate. In Jamaica it appears that mould begins entering the bean about the fourth day of drying, but I wonder if these moulds have been identified by pathologists before that stage.

Mr. G.A.R. Wood (United Kingdom)

I should like to refer to work on driers in the Cameroons where at one stage the driers were overloaded and the operators removed some of the cocoa so that the balance could dry satisfactorily. The cocoa that was removed quickly developed moulds; the mould was external and much less than 5 per cent. The cocoa pro-

duced from this sample was very strong in flavour. I believe tha something like 2 or 3 per cent. of mould on the bean is sufficie to affect the flavour of the final product.

Mr. J. Braudeau (France)

No direct colour in the bean has been established as a resul of mould infestation, but we find that in general mouldy beans, when fermented, obtain a darker colour.

Mr. St.G. Cooper (Trinidad and Tobago)

The papers presented have shown that there are large gaps in our knowledge of the chemistry of fermentation. In view of the fact that traditional methods of cocoa fermentation appear to be superior to existing chemical and technological knowledge, why should manufacturers insist on such high quality, and is the apparent decline in quality of raw material reflected in the product to the consumer?

Mr. G.A.R. Wood (United Kingdom)

Manufacturers do not insist on very high quality. Their standards are that acceptable cocoa should contain not more than 5 per cent. defective or mouldy beans. Large manufacturers can eliminate variations in the quality of beans during the manufacturing process but the smaller manufacturer encounters a lot of difficulty.

Sr. B. Cardenosa (Colombia)

There is a marked correlation between the fermentation process and the level of quality of the finished product. Manufacturers in my country find it necessary to make further studies in this correlation and at present we are carrying out research to assess this. In Colombia at present we are concerned with the quality of cocoa, in particular, the final stage, and we find it necessary to carry out work into the different types of processin necessary according to the varying quality of the bean. We are hoping to start a differential price system so that the grower with a better product will achieve a benefit; the better product when processed, will of course command a higher market price.

LA LUTTE CONTRE LES MOISISSURES DU CACAO MARCHAND DANS L'OUEST AFRICAIN

R. Renaud[*]

Dans les pays africains de langue française le déclassement d'un lot de cacao marchand est le plus souvent du a une proportion trop forte de fèves moisies. Les normes en vigueur sanctionnent durement ce défaut: pour être classé en type "supérieur" ou "courant" un lot doit présenter, parmi les autres défauts, moins de 5% de fèves moisies et moins de 10% pour entrer dans la catégorie "limite". De plus certains pays, tels que la République de Côte d'Ivoire, ont pris des mesures visant à interdire l'exportation de la catégorie "limite".

Le "vice propre" du cacao (présence de moisissures internes) constitue donc un problème dont l'importance économique peut se trouver accrue, certaines années, par des conditions météorologiques particulièrement favorables au développement des organismes responsables.

Sur ce problème des moisissures toute une série d'importants travaux furent effectués, aux alentours de 1930, en Europe (PASSMORE), en Amérique (CIFERRI), au Nigeria (LAYCOCK) et surtout en Gold Coast (BUNTING, DADE, SCOTT, etc.). Ces travaux permirent de déterminer les organismes les plus fréquents et de préciser leurs conditions de développement.

Ils montrèrent en particulier que certaines moisissures peuvent pénétrer dans la fève au cours de la fermentation et, surtout, mirent en évidence l'importance capitale de la teneur en eau du produit: au dessous d'un pourcentage estimé à 8% d'eau - ce qui correspond à un état hygrométrique de 82[(1)] - même, les espèces les moins exigeantes sont incapables de se développer.

A partir de 1950 et surtout à la suite des proportions désastreuses prises par le "vice propre" en Côte d'Ivoire au cours de la campagne de traite 1952-53, l'auteur a été conduit à étudier de nouveau ce problème et à tenter de préciser certains points.

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[*] Phytopathologiste du Service de Défense des Cultures de l'Office de la Recherche Scientifique et Technique, Outre-Mer, Nogent sur Marne, France

(1) Ce chiffre correspond aux résultats de SCOTT (1929). Les chiffres donnés par Melle SAUDA (1957) sont différents: à une température de 30° C et à 83% d'humidité relative la teneur en eau du cacao à l'équilibre est de 9% et, pour 73%, de 8%.

Les mesures que l'on peut envisager contre le "vice propre" peuvent être de trois ordres:

a) Effectuer la préparation du produit de telle façon que les risques de moisissures soient réduits au minimum;

b) Empêcher ou limiter le développement des moisissures dans le produit commercial;

c) Chercher à éliminer plus ou moins complètement les fèves moisies lorsque le produit en présente une proportion trop importante.

Les essais de l'auteur en Côte d'Ivoire démontrèrent que l'état des cabosses dont sont issues les fèves mises a fermenter à une influence considérable sur les risques de moisissures courus par le produit marchand. Le cacao provenant de cabosses pourries, même partiellement, peut présenter au bout de quelques mois cinq à vingt fois plus de fèves moisies que le cacao, préparé et conservé dans les mêmes conditions, mais provenant de cabosses normales.

Les cabosses surmuries fournissent également un produit très nettement plus sensible aux moisissures. Enfin les cabosses dont le cortex, endommagé au cours de la récolte, a laissé pénétrer suffisamment d'air pour permettre le développement de saprophytes dans la pulpe et un début du processus de germination, donnent, lorsque la mise en fermentation tarde quelque peu, un cacao encore plus sensible aux organismes responsables du "vice propre" que celui provenant des cabosses pourries.

Les observations de l'auteur confirmèrent que les risques de moisissures s'accroissent tres rapidement avec la durée de la fermentation. Ainsi, après 3 mois de conservation, on observa 38% de fèves moisies dans un lot surfermenté (228 heures) contre 2,5% seulement pour le cacao normalement fermenté (158 heures) cependant que le produit sous-fermenté (72 heures) n'en présentait pratiquement pas.

Les moisissures qui se développent assez fréquemment dans les bacs à fermentation paraissent favorisées par l'aération résultant d'un faible tassement de la masse: leur action est considérable. Dans un tel cas les fèves fermentées prélevées dans la partie d'un bac envahie par des moisissures sporulées comportaient, au bout de 3 mois, 48,3% de fèves moisies contre 2,2% seulement parmi celles prises dans la partie non envahie du même bac.

Le lavage des fèves après fermentation est réalisé dans certains pays producteurs. En Côte d'Ivoire un essai de ce traitement donna des résultats déplorables. La coque se brise plus facilement

et, après 45 jours de conservation, le cacao lavé comprenait plus de vingt cinq fois plus de fèves moisies que celui non lavé.

La lenteur du séchage, comme l'a montré DADE en particulier, accroît l'importance des moisissures. Les essais de l'auteur ont porté sur le séchage solaire dont la rapidité variait avec l'épaisseur de la couche de feves, la fréquence des brassages, la position des claies (placées en plein soleil ou laissées sous abri) etc. Suivant les lots le pourcentage de fèves moisies enregistré, differa parfois dans des proportions de 1 à 10 voire d'avantage.

Un essai de séchage sur aire cimentée donna un produit qui, au bout de 3 mois et demi de conservation présentait soixante dix fois plus de moisissures que des feves ayant reçu les mêmes soins mais séchées sur nattes. Il est vraisemblable que le contact du ciment diminua l'acidité des téguments en début de séchage: les observations de LAYCOCK (1928) ont d'ailleurs montré que l'alcalinisation de la coque favorise le développement des moisissures.

Dans le second groupe de mesures la conservation du produit en atmosphère sèche se situe au tout premier plan. L'humidité atmosphérique, dans les centres producteurs de l'Ouest Africain, est presque toujours suffisante pour permettre un développement rapide des moisissures. A défaut d'installations spéciales il peut suffire, pour éviter qu'un cacao convenablement préparé ne subisse un déclassement, d'accelerer son exportation. Il faut, avant tout, éviter le stockage prolongé chez le producteur: c'est pourquoi l'importance du problème du "vice propre" est en grande partie fonction du système de commercialisation.

Cependant, si l'évacuation n'est pas suffisamment rapide, on peut chercher a retarder la reprise d'humidité par le cacao convenablement séché. L'architecture des magasins et entrepôts peut être déterminante à cet égard. D'autre part la nature des emballages agit largement. WILBAUX (1937) a observé que les sacs doublés de papier qu'il conseille contre les insectes, retarde cette reprise d'humidité. Au Cameroun ALLERS & PUJEBET montrèrent l'efficacité de la conservation en sacs de polyéthylène: dans de tels sacs un cacao comprenant initialement 1,66% de fèves moisies et séché à 6,5% d'humidité au début de l'essai, après 4 mois de conservation en saison des pluies, ne présentait encore que 2,22% de fèves moisies alors que ce même produit, conservé en sacs de toile, en comprenait 5,64% au bout de 2 mois, 12,71% au bout de 3 mois et 59,02% au bout de 4 mois. Pour un taux d'humidité initial de 8,2% ou de 9,4% les différences furent un peu moins spectaculaires.(2)

(2) Une expérience du Service du Contrôle du Conditionnement du Cameroun montra, qu'un cacao comprenant initialement 8,45% de fèves moisies avec une teneur en eau de 6,9%, après 103 jours de conservation sous hangar, en sac de polyéthylène, ou en sac de jute, contenait 7,2% d'eau et présentait 15,2% de fèves moisies dans le premier cas mais que ces chiffres, pour l'emballage normal, étaient portés à 10,8% d'eau et

Ces mêmes essais montrèrent aussi qu'à une température égale ou inférieure à 10° C le développement des moisissures est insignifiant. Cette constatation semble malheureusement n'avoir guère de chances de recevoir une application pratique dans les pays producteurs.

Enfin, s'il est prouvé qu'une teneur en eau de 8% environ peut suffire au développement de certains organismes sur les cotyledons, il se peut que leur pénétration dans une fève aux téguments intacts exige une humidité nettement plus forte. On peut supposer que, dans bien des cas, cette pénétration aurait lieu très précocement au cours de la fermentation et du séchage, la moisissure ne devenant "commercialement" visible qu'ultérieurement sous certaines conditions d'humidité et de température. Cette hypothèse, en cours de vérification, fournirait une explication pour certaines des observations faites en Côte d'Ivoire au sujet de l'influence de la conduite de la fermentation et du séchage sur les "risques de moisissures"du produit obtenu. Elle permettrait en outre d'envisager des méthodes de lutte visant à éliminer, à l'intérieur même des fèves, les organismes avant leur développement "commercial".

Des essais d'ALLERS & PUJEBET, ont d'ailleurs montré que la fumigation du cacao à l'oxyde d'éthylène sous vide préalable, réduisait très sensiblement le développement intérieur des moisissures. Conservé pendant deux mois en sacs de toile, le produit ayant une teneur en eau initiale de 6,5% et traité aux doses de 104, 156 et 208 grammes d'oxyde d'éthylène par mètre cube présentait 3,91, 2,93 et 2,49% de fèves moisies contre 5,64% pour le produit non traité. Avec une teneur en eau initiale de 9,4% les chiffres obtenus étaient respectivement de 23,92, 10,85, 10,53 et 26,50.

Conservé en sacs de polyéthylène le produit présentait des pourcentages de fèves moisies très voisins quelque soit le traitement subi.

Un premier essai de traitement par radiations ionisantes fût effectué par les Services de Technologie, de Radiobiologie et de Défense des Cultures de l'O.R.S.T.O.M. On put ainsi observer dans les premiers jours suivant le traitement un ralentissement du développement des moisissures d'autant plus net que la dose de radiations appliquée avait été plus forte (25.000, 50.000 et 100.000 Roentgen). Ce ralentissement était cependant trop fugace pour offrir un intérêt pratique. Il est prévu de nouveaux essais avec des doses beaucoup plus élevées mais il est alors à craindre que la qualité du produit ne soit altérée.

Par ailleurs des essais de traitement par rayonnement infrarouge sont en cours.

En troisième lieu on peut envisager d'améliorer la qualité d'un lot de cacao dépréciée par suite d'un pourcentage trop élevé de fèves moisies. En Côte d'Ivoire l'auteur a pu mettre en évidence des corrélations, souvent étroites, entre la probabilité pour une fève d'être moisie intérieurement et les caractères physiques de cette fève.

Ces caractères, qui reflètent les conditions de préparation et de conservation du produit sont en particulier la forme générale de la fève, l'aspect et la couleur de la coque, son intégrité et la présence plus ou moins accusée de déchets à sa surface, la couleur et la compacité des cotylédons.

C'est ainsi que les fèves dont la coque est fortement ridée (ce qui résulte le plus souvent d'un séchage rapide) présentaient environ quatre fois moins souvent de moisissures internes que celles à coque lisse. Les fèves aux téguments intacts en présentaient trois à quatre fois moins souvent que les fèves à téguments détériorés (germination, brisure, etc.). En divisant un échantillon de cacao marchand en deux parties à peu près égales selon la forme des fèves on a pu constater que les fèves plus ou moins applaties étaient environ trois fois plus atteintes que les fèves plus dodues. Quant à la présence plus ou moins abondante de déchets adhérant aux coques les résultats diffèrent du tout au tout suivant le lot examiné, sans doute en raison de phénomènes d'antagonisme microbiens.

Dans un même lot commercial les fèves normalement fermentées ont au moins trois fois plus de chances d'être moisies que les fèves ardoisées ou violettes, et les fèves aux cotylédons les plus clairs sont près de dix fois moins exposées que celles aux cotylédons les plus foncés.

Toujours dans un même lot, les fèves dont la coque est d'une teinte brun clair tirant sur le jaune paille présentent environ dix fois moins souvent de moisissures internes que celles à coque gris noirâtre. Enfin, dans les observations de l'auteur, les fèves à amande très compacte n'étaient jamais attaquées par les moisissures alors que celles dont les replis des cotylédons étaient largement séparés, en présentaient dans 10 à 50% des cas.

La liaison entre la probabilité de la présence de moisissures internes et ces deux derniers caractères au moins - compacité de l'amande (et, par conséquent, densité de la fève) et couleur de la coque est susceptible d'être exploitée dans la pratique. Il est prévu de prochains essais de triage du produit, basés sur la couleur externe, à l'aide d'appareils commerciaux. Il n'est malheureusement pas certain que les cellules photo-électriques de ces appareils puissent séparer assez rigoureusement les fèves dont la teinte est légèrement bleutée de celles dont la couleur tire nettement vers les rouges et les jaunes. De plus leur débit horaire est réduit.

Par contre des essais préliminaires de triage densimétrique ont donné des résultats très encourageants. L'appareil utilisé est basé sur le principe suivant: un courant d'air, pulsé de bas en haut et également réparti traverse une table oscillante inclinable dans le sens longitudinal et le sens transversal. Les produits les plus lourds, entraînés par les oscillations, sortent à une extrémité de cette table de travail et les produits légers, soutenus par le courant d'air ascendant sont récupérés à l'autre extrémité.

Dans le cas du cacao la plupart des fèves moisies, mitées ou germées et la presque totalité des fèves plates se retrouvent parmi les produits legers. En contre partie les fèves ardoisées et les fèves violettes sont plus abondantes parmi les produits lourds. Cependant, d'un lot inexportable comportant initialement 11,6% de fèves moisies, on a pu tirer environ 85% de cacao "limite" avec un débit horaire de 1.800 kilogrammes et 90% en abaissant ce débit à 1.200 kg/heure. Avec un lot de classement "limite" dont le pourcentage initial de feves moisies atteignait 7,9% on a pu, ou bien obtenir 75 à 80% de cacao "supérieur", les 20 a 25% restants étant éliminés en "hors normes", ou bien ne conserver que 25 à 30% du lot initial en type "supérieur" de façon à ce que l'autre partie reste de classement "limite" avec, au plus, 10% de fèves moisies.

Pour des lots dont le pourcentage de feves moisies excède d'assez peu les normes du conditionnement, ce mode de triage parait donc très rentable d'autant plus que les resultats pourront certainement être améliorés au cours des essais ultérieurs par certaines modifications mineures de l'appareil, par des règlages mieux étudiés et enfin par un eventuel recyclage des produits de densité intermédiaire. Par contre pour les lots très fortement attaqués, présentant plus de 30% de feves moisies la rentabilité, sinon l'efficacité, de l'opération ne semble pas certaine.

Il est donc possible d'agir efficacement contre le "vice propre" du cacao depuis la récolte des cabosses jusqu'à l'exportation du produit marchand. Cependant les mesures les plus simples restent les plus efficaces et les plus rentables: une fermentation bien conduite éliminant les fèves des cabosses anormales, un séchage rapide et suffisamment poussé et, plus encore peut être, une exportation suivant d'aussi près que possible la préparation du produit, doivent suffire dans presque tous les cas à assurer au cacao marchand une qualité satisfaisante que les moisissures internes ne peuvent abaisser notablement. Mais lorsque toutes ces conditions n'ont pu être réunies, on peut encore prévenir un développement exagéré des moisissures. Des magasins bien conçus retarderont la reprise

d'humidité par le produit et l'usage du polyéthylene, soit pour doubler les sacs, soit sous forme de baches recouvrant les piles de sacs, parait permettre de conserver longtemps à peu près inchangée la teneur en eau d'un cacao préablement bien séché. Les méthodes visa t à détruire les moisissures avant qu'elles se soient développées d'une manière visible à l'intérieur des fèves semblent d'application plus restreinte, que l'on envisage les fumigations, les radiations ionisantes ou le rayonnement infra-rouge. Ce dernier pourrait cependant être utile dans le cas de lots mal séchés.

Enfin, un lot dont la qualité se trouve abaissée par le "vice propre" peut être, très rentablement, reconditionné par un triage densimétrique éventuellement associé à un second triage basé sur la teinte extérieure des fèves.

RESUME

Les moisissures internes(ou "vice propre") des fèves de cacao fermentées restent le plus grave défaut de ce produit dans les pays africains de langue française. Les mesures que l'on peut envisager sont de trois ordres:

1. Il convient d'abord d'effectuer la fermentation et le séchage de telle sorte que le cacao coure le moins possible de risques de se moisir. L'état des cabosses récoltées, la conduite et surtout la durée de la fermentation, la rapidité du séchage jouent un rôle considérable.

2. Le produit doit être conservé dans des conditions de milieu défavorables au développement des organismes responsables. L'architecture des batiments de stockage doit en particulier, chercher à limiter la reprise d'humidité par le cacao. Lorsque l'exportation est tardive l'usage du polyéthylène s'est montré intéressant à cet égard.

Comme il est possible que la pénétration des moisissures dans la fève ait lieu très précocement, on a cherché à les éliminer avant que leur développement ne soit devenu commercialement visible. Des essais de traitements par fumigation à l'oxyde d'éthylène, par radiations ionisantes et par rayonnements infra-rouge, ont été effectués ou sont en cours.

3. Grâce aux corrélations qui existent entre la probabilité pour une fève d'être moisie intérieurement et certains caractères de cette fève (couleur externe et densité en particulier) on peu améliorer la qualité d'un lot commercial. Des essais préliminaires de triage densimétrique ont donnés des résultats très encourageants.

SUMMARY

The internal mould (moisissures internes ou "vice propre") of the fermented cacao bean is still considered the major defect of this product in the French-speaking countries of West Africa.

Measures to prevent mould development in the fermented bean are described below:-

1. It is first of all considered essential to ferment and dry the cacao in such a manner as to reduce the possible danger of mould development in the bean. The maturity of the pods harvested, the way of fermenting and the time of this process, as well as the shortness of the drying of the beans, are important.

2. The product has to be stored under conditions unfavourable for the development of the organisms responsible for the formation of mould. The storage rooms have to be constructed in such a manner as to avoid the uptake of humidity by the cacao. If the export of cacao is delayed, the use of polyethylene bags has proved helpful in this respect.

3. Since it is possible that mould penetrates the beans at a very early stage, efforts have been made to prevent the development of the organism before it became commercially visible. Several treatments have been tried, including fumigation with ethyl oxide, ionised radiation and by radiation of infra-red light.

4. Since a correlation between the probability that a bean has internal mould and certain characters of this bean (outside colour, and density in particular) exist, it has been possible to improve the quality of a commercial lot. Preliminary experiments with densimetrical sorting have given encouraging results.

RESUMEN

Los hongos internos (moisissures internes ou "vice-propre") de las almendras fermentadas de cacao son considerados todavía como un defecto grande de este producto en los países de habla francesa del Africa Occidental.

A continuación se describen las medidas para prevenir el desarrollo de hongos en almendras fermentadas:

1. Se considera primero esencial fermentar y secar el cacao de tal manera que reduzca el posible peligro de desarrollo de hongos en las almendras. Son importantes los factores como la madurez de la mazorca cosechada, la forma y tiempo de fermentación y el período del secado.

2. El producto tiene que almacenarse en condiciones desfavorables para el desarrollo de los organismos responsables para el crecimiento del hongo. Los cuartos de almacenaje deben ser construidos de tal manera que no permitan que el cacao absorba la humedad. Si se demora la exportación del cacao, el uso de bolsas de polietileno ha mostrado ser provechoso para este objeto.

3. Ya que es posible que los hongos penetren en las almendras muy temprano, se ha hecho esfuerzos para prevenir el desarrollo del organismo antes de que sea comercialmente visible. Se han tratado algunos tratamientos, incluyendo fumigaciones con óxido etílico, radiaciones ionizantes y radiaciones con luz infra-roja.

4. Del hecho que existe una correlación entre la probabilidad que una almendra tenga moho internamente y algunas características de esta almendra (color externo y densidad en particular), ha sido posible mejorar la calidad del cacao comercial. Experimentos preliminares de clasificación por densimetría han dado resultados alentadores.

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PAPERS ON HORTICULTURE, PROPAGATION AND GROWTH PHYSIOLOGY

EFFECTS OF PHOTOPERIOD AND KIND OF SUPPLEMENTAL LIGHT ON THE GROWTH OF THEOBROMA CACAO

A. A. Piringer and R. J. Downs*

INTRODUCTION

Growth of young seedling cacao plants was affected by photoperiod in 1956 and 1957 at Beltsville, Maryland. Short-stemmed plants developed on photoperiods of 12 hours or less, while long-stemmed plants developed on photoperiods of more than 12 hours. Flowering was earliest on the longer photoperiods. The experiment reported herein was done at Beltsville between October 195[illegible] and March 1960 to determine more precisely the responses of cacao to various photoperiods.

MATERIALS AND METHODS

Young plants of Theobroma cacao L. were grown from seed from Costa Rica. Unopened seed pods, developed from open-pollinated flowers, were obtained from a clone designated as UF 667.** The seeds were germinated in the dark on wet blotters in moist temperature-controlled chambers at 25°C. When the radicles appeared, the seedlings were transplanted to sphagnum in 7.5-cm clay pots and placed in the greenhouse on natural days at a minimum temperature of 21°. Before the cotyledons had expanded, the seedlings were repotted in soil, one per pot, and started on their respective photoperiod treatments on October 17, 1958.

Groups of five plants each were grown on photoperiods of 8, 12, 14, 16 and 24 hours and on a 12-hour photoperiod with a 1-hour light interruption near the middle of the 12-hour dark period. Hereafter, the last treatment is called the interrupted night and the 24-hour treatment is called continuous light.

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* U.S. Department of Agriculture, Agricultural Research Service, Crops Research Division, Plant Industry Station, Beltsville, Maryland, USA.

** Seed pods were provided by the Cacao Center, Inter-American Institute of Agricultural Sciences, Turrialba, Costa Rica.

The plants were kept on carts in the greenhouse and all plants received 8 hours of natural light daily from 8 am. to 4 pm. At 4 pm. the carts were moved into adjoining ventilated chambers. The 8-hour plants went immediately into the dark, and the other groups received additional hours of illumination from automatically controlled incandescent light sources to fulfill their photoperiods or to provide the light interruption of the 12-hour dark period. The kind of supplemental light, incandescent or fluorescent, used to extend the photoperiod was known to have a differential effect on the growth of many plants (2). To test any such differential response of cacao an additional 16-hour group, called the 16-hour fluorescent treatment in the text, received its supplemental light from a fluorescent source. The incandescent light source was 100-watt lamps spaced to provide a uniform illumination of about 30 footcandles at plant level at the start of the experiment. The fluorescent source, which also provided an illumination of 30 footcandles at plant level, consisted of two 30-watt standard cool white lamps. As the experiment progressed the tips of the growing plants approached the lamps and were thus at a somewhat higher intensity.

The dark chambers, ventilated by forced air from outdoors, were thermostatically controlled at 21°C except for some periods during July and August, when natural night temperatures were higher. The greenhouse temperature was thermostatically controlled to provide a minimum of 21°C. The maximum day temperature when the plants were in the greenhouse, was kept below 27°C except for a few weeks during midsummer.

The plants were repotted in soil as necessary and were ultimately grown in 20-cm clay pots. The mineral nutrition requirements of slowly growing plants on short daylengths is different from that of actively growing plants on long days (5). Our own experience with woody plants showed that a given amount of fertilizer added to the soil can be toxic to plants on short days and stimulatory to one on long days. To minimize the stimulatory effects of supplemental nutrients the plants in this experiment were not fertilized. The greenhouse was partially shaded from April to September by externally whitewashing the glass.

A seedling cacao plant forms a straight main stem and then forks into three to five main limbs, forming the so-called fan growth, or "jorquette". The criteria of response in this experiment were the length and node number of the main stem, days of treatment to the "jorquette", the number and lengths of the "jorquette" branches, and the time of flowering.

Final lengths of stems and branches were recorded on January 31, 1960, after 64 weeks of treatment, because the plants on long days became too tall for the growth chambers. Shorter plants that had not jorquetted by that date were [illegible] on treatments until jorquetting occurred or until the experiment was terminated on March 1, 1960.

The data were subjected to analysis of variance and the significances of mean differences were compared with the Duncan multiple-range test (4). The "within cart" variation was used as a measure of experimental error for all tests.

RESULTS

The increased lengthening of the main stem on daylengths longer than 12 hours was apparent within 6 months. After 10 months of growth, stem lengths of plants on 8-hour photoperiods differed significantly from those of plants on 16-hour photoperiods. Stem lengths of plants were shorter on 8-hour and longer on 16-hour photoperiods than stem lengths of plants on the remaining photoperiods (Fig. 1). The differences in stem length were due primarily to longer internodes on the long days.

After 16 months in the greenhouse main stems on 8-hour days were significantly shorter than those on 12 hours, 14 hours, 16 hours, and the interrupted night, but were not statistically different than those on the 16-hour fluorescent and on the continuous light (Table 1). The longest stems occurred on the 16-hour photoperiod and on the interrupted night. Stems of plants on the 8-hour and 16-hour fluorescent light had the fewest nodes. Stems of plants on the interrupted night had the most nodes. Mean internode lengths of stems were shortest on the 8-hour photoperiod and longest on the 16-hour incandescent photoperiod. Internode lengths of stems on other treatments were not significantly different from each other. The shorter stems on 8-hour photoperiods were, therefore, due to fewer nodes and shorter internodes. Conversely, the longer stems on the 16-hour photoperiod were due to more nodes and longer internodes. The longer stems of plants on the interrupted night were due to an increased number of nodes.

Total growth, measured as length of the main stem and each shoot of the fan growth, was short on 8 hours, 12 hours, and continuous light; and it was intermediate on 16-hour fluorescent and on the interrupted night. It was long on 14-hour and 16-hour photoperiods because most plants on these two photoperiods had jorquetted early and had some fan growth. Few plants on 8 hours, 12 hours, and continuous light had jorquetted within 16 months. The increased length due to fan growth on 14-hour and 16-hour photoperiods was about 60 cm. Less fan growth (total length minus stem length) on plants on the 16-hour fluorescent treatment was due primarily to shorter internodes, while on the interrupted night less fan growth was due to delayed jorquetting. There was little difference between main-stem and total lengths of plants on 8 hours, 12 hours, and continuous light because little or no fan growth occurred.

During 18 months in the greenhouse, all plants jorquetted on 14 hours, 16 hours, 16 hours of fluorescent light, and the interrupted night (Table 2). To facilitate the analysis of variance of the period for jorquetting, the total number of days for the experiment was used as the number of days for jorquetting of the plants not jorquetted during the experiment on 8 hours, 12 hours, and continuous light. Jorquetting was observed first on the 16-hour photoperiod and finally on continuous light. The mean number of days for jorquette formation was the same on the 14-hour, 16-hour, and 16-hour fluorescent photoperiods. It was somewhat later on the interrupted night and markedly delayed on 8 hours, 12 hours, and continuous light.

Plants on all treatments produced five fan branches per jorquette except on the 8-hour photoperiod, where the two jorquetted plants each produced only three fan branches.

The characteristics of the main-stem growth to the jorquette did not differ basically from those described for the stem in table 1.

Flowering did not occur during the experiment.

Table 1. Growth* of Theobroma cacao seedling plants during 16 months in the greenhouse on various photoperiods, and with two light sources on one of the photoperiods.

Photoperiod hours	Supplemental light: Duration hours	Supplemental light: Kind	Main stem: Length cm	Main stem: Nodes number	Main stem: Mean internode length cm	Total length (stem and branches) cm
8	0	None	85.2 C	56.6 B	1.50 c	93.6 C
12	4	Incandescent	117.2 AB	67.8 AB	1.73 ab	117.4 C
14	6	Incandescent	112.0 AB	62.4 B	1.78 ab	173.3 A
16	8	Incandescent	128.0 A	68.4 AB	1.89 a	188.4 A
16	8	Fluorescent	103.0 BC	60.8 B	1.69 abc	145.5 B
Continuous	16	Incandescent	104.4 BC	64.6 AB	1.64 bc	104.4 C
12 + 1	4+1	Incandescent	128.6 A	80.2 A	1.61 bc	142.2 B

* Five plants per treatment. Different upper-case letters after values indicate that they are significantly different at the 1-percent level, and different lower-case letters that values are significantly different at the 5-percent level. The same letters indicate no statistical difference.

Table 2. Jorquette formation on the main stems of Theobroma cacao seedling plants during 18 months in the greenhouse on various photoperiods, and with two light sources on one of the photoperiods.

Photo-period hours	Supplemental light: Duration hours	Supplemental light: Kind	Plants jorquetted number	Period required for jorquette formation: Range days	Period required for jorquette formation: Mean* days
8	0	None	2	362 - 495**	453.8 ab
12	4	Incandescent	3	456 - 495**	480.8 a
14	6	Incandescent	5	363 - 463	400.0 b
16	8	Incandescent	5	323 - 475	400.2 b
16	8	Fluorescent	5	344 - 474	401.4 b
Continuous	16	Incandescent	1	466 - 495**	489.2 a
12+1	4+1	Incandescent	5	372 - 476	443.4 ab

* Five plants per treatment. Different lower-case letters after values indicate that they are significantly different at the 5-percent level. The same letters indicate no statistical difference.

** The number of days of treatment to the end of the experiment.

DISCUSSION AND SUMMARY

The cocoa plant responded visibly to different photoperiods relatively early during its growth and tended to grow faster on photoperiods longer than 12 hours. Plants developed the shortest main stems on 8-hour photoperiod and longer ones on the 16-hour photoperiod and the interrupted night. The long stems were due mainly to greater internode lengths on the 16-hour photoperiod and to more nodes on the interrupted night. Jorquetting was early on the 16-hour photoperiods regardless of the kind of supplemental light, but in the fluorescent light the stems were significantly shorter. Continuous light was little more effective than an 8-hour photoperiod. The response of the plants to a 1-hour incandescent light break was essentially that to a long day.

All plants on 14 hours, 16 hours, 16 hours of fluorescent light, and the interrupted night jorquetted relatively early. All plants did not jorquette within the 18-month experimental period on the 8-hour, 12-hour, and continuous-light treatments and those plants that jorquetted did so late in the growth period. A single exception occurred when one plant on the 8-hour photoperiod jorquetted somewhat early.

All plants jorquetted early on the 16-hour photoperiod and were similar regardless of the source of supplemental light (Table 2). Stem characteristics, however, were rather different. When fluorescent supplemental light was given, plants had stems as short as those of plants on photoperiods shorter than the given 16 hours, and total growth was less than that on the 16-hour photoperiod with incandescent light. The shorter main stems and less total length on the fluorescent treatment were due partly to fewer nodes but mainly to shorter internodes (Table 1). These results are consistent with similar differential responses of other plant materials to the two light sources (2,3,10) and were attributed to the relative ratios of red and far-red radiant energies emitted by the two light sources. In general, far-red radiation promotes elongation of internodes and red radiation has the opposite effect. The fluorescent lamp emits a very low amount of far-red compared with red, whereas the incandescent lamp emits a high proportion of far-red energy (2).

Plants on the interrupted night had longer stems and more total growth than plants without the light interruption. The longer stems were due to more nodes and the greater total growth was due to earlier jorquetting. The stem length of plants and number of plants jorquetted on the interrupted night were similar to those of plants on a 16-hour photoperiod, but more nodes were produced with accompanying shorter internodes on the interrupted night. In

general, the effect of the 1-hour light-break of a 12-hour night was that of a 16-hour daylength. Response to the light-break as to a long day is consistent with that of temperate-zone plants.

Theobroma cacao is a tropical woody plant grown where seasonal fluctuations in daylength are often assumed to be too slight to influence growth. The limits of cacao cultivation are about 20°N and 20°S latitude, with the bulk of the crop within 10° of the Equator. Daylengths measured from sunrise to sunset at 20° have an approximate seasonal range of 10.9 to 13.3 hours. At lower latitudes the ranges, of course, become still narrower. Njoku (7) studied certain herbaceous economic plants in Nigeria at about 7°N latitude and found that their critical photoperiods were very narrowly defined and a difference of 15 minutes in the daylength determined flowering or vegetative growth. His studies supported those of Sircar (11) and Bünning (1), who held that many tropical plants were very highly sensitive to photoperiodic stimuli.

The present experiment showed that Theobroma cacao was sensitive to photoperiod as were other tropical woody plants such as Tephrosia candida (6), Coffea arabica (8), and Rauvolfia vomitoria (9). In some respects the growth responses of Theobroma cacao and Rauvolfia vomitoria are strikingly similar. Both are dimorphic, their main stems develop to a given point at which a whorl of branches arises accompanied by a change in the morphology of the new growth. On Theobroma cacao plants this whorled branching, the jorquette, occurred within 60 to 70 nodes. The exception was on the interrupted-night treatment, where the number of nodes to the jorquette was markedly greater. On Rauvolfia vomitoria the main stem characteristically developed about 18 nodes before producing its whorl of branches (9). Rauvolfia vomitoria and Theobroma cacao were photoperiodically similar since, in each case, long daylengths stimulated the more rapid formation and development of the required number of nodes to the point of branching and hence branching was earlier.

Cacao plants did not flower within 18 months of treatment in this experiment but had flowered within that time in earlier experiments. However, plants used in earlier experiments were initially about 3 months older and represented a mixture of clones. The delayed flowering in this experiment might be due either to the experimental plants being younger or to the clones being earlier flowering.

The rate and extent of the growth of cocoa plants can be stimulated beyond that possible by the plant in its natural photoperiodic environment. The stimulation can be accomplished in

the Tropics by giving a light-break in the middle of the natural night or extending the natural day to 16 hours with supplemental light. The kind of supplemental light used to extend the day will to some degree affect the rate and type of growth obtained.

SUMMARY

Cacao seedlings were grown for 18 months under photoperiods of 8 hours, 12 hours, 12 hours with a one hour interruption near the middle of the night, 14 hours, 16 hours and 24 hours.

The different photoperiods were given as supplements to 8 hours of natural daylight in a greenhouse, using incandescent light of low intensity. There was one additional treatment with a 16-hour day, using flourescent light.

The plants responded rapidly to the different photoperiods. The shortest-day plants had the shortest stem lengths, and the 16-hour day gave the greatest stem lengths, due largely to lengthening of the internodes. The plants subjected to photoperiods of 14 and 16 hours and an interrupted night jorquetted earlier. The treatment with 8 hours of natural light and 8 hours of supplementary flourescent light gave similar effects to a long day in jorquette formation but to a short day in stem growth. Continuous light reduced growth. Growth responses with the interrupted night were similar to those with photoperiods greater than 12 hours.

RESUMEN

Se cultivaron plantitas de semilla de Theobroma cacao por 18 meses con fotoperíodos de 8, 12, 12 horas con una hora de interrupción en la media noche, 14, 16 y 24 horas.

Los diversos fotoperíodos se consiguieron extendiendo las 8 horas de luz natural, en el invernadero, con luz suplementaria incandescente de baja intensidad. Se usó un tratamiento adicional de 16 horas con luz suplementaria fluorescente, para averiguar el efecto diferente sobre el crecimiento.

Las plantas respondieron relativamente rápido a los diferentes fotoperíodos. Los tallos más cortos correspondieron al tratamiento de apenas 8 horas y los más largos a 16 horas de luz, debido principalmente a los entrenudos más largos. Con fotoperíodos de 14 y 16 horas y de noche interrumpida, las plantas formaron "horqueta" más temprano. El tratamiento con 8 horas de luz natural extendido a 16 horas de luz fluorescente se caracterizó como un día largo en la formación de "horqueta", pero como día corto en el crecimiento del tallo. La luz continua produjo un crecimiento menor. Con el tratamiento de noche interrumpida, las plantas respondieron igual que con fotoperíodos mayores de 12 horas.

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SUMMARY OF DISCUSSION

Mr. G.C. Van den Berghe (Cuba)

What do you mean by "far-red" after referring to fluorescent light and to incandescent light?

Mr. J.L. Creech (U.S.A.)

The part of the spectrum above the red, not below, as given by the fluorescent light.

Sr. G. Rubio (Ecuador)

I refer to the work being done at Turrialba on the reaction of plants to photoperiod effects. This work was initiated on the basis of results on the paper that was just read, the objectives being to determine the reaction on cacao plants. We utilise plants of UF 113 and seedlings of the hybrid cross of SCA 6 x ICS 1, the plants being about twelve months old. Treatments are 8, 12, 16 and 20 hours of light with one hour of interruption at night. In addition, all plants receive eight hours of natural light. We are hoping to induce flowering with some of the photoperiods, we then plan to pollinise plants with compatible clones. This trial has been going on only for one month so that to date we cannot say much about the reaction of the plants to photoperiods.

Mr. D.B. Murray (ICTA)

It is interesting to hear the effects of photoperiod on cocoa and I should like to know more of the effect of flowering. Under field conditions there are main periods of flowering but we do know the tree can flower all through the year. Can the speaker tell us something more as to whether these effects were also evident in increasing the amount of flowers set on the plant.

Mr. J.L. Creech (U.S.A.)

We have nothing conclusive on which we can commit ourselves at this time. I think you should contact the author direct.

EFECTO DEL ALMACENAJE SOBRE LA VIABILIDAD DEL POLEN DE CACAO*

Jacinto Varas A.,** E. T. Bullard***

INTRODUCCION

El problema de la conservación de la viabilidad y del almacenamiento de polen ha interesado a quienes de dedican al mejoramiento genètico del cacao, mediante hibridación controlada.

El peligro que trae consigo el intercambio de materiales de propagación entre diferentes lugares o zonas geográficas productoras de cacao se relaciona principalmente con la introducción de plagas o enfermedades, existentes en unas zonas y ausentes en otras, como hinchazón de los brotes y Escoba de Bruja. Podrían evitarse en gran parte estos peligros, usando polen viable como material de intercambio.

El programa de fitomejoramiento del cacao de varios países, tiene como base fundamental la hibridación; a su vez este programa presenta el inconveniente de limitaciones de existencia del material que posee una estación experimental. La posibilidad de intercambio de polen entre los centros de investigación de diversos países, ayudaría mucho en los programas de mejoramiento del cacao.

Lawrence (4) dice: "El hecho de que el polen de muchas plantas se pueda guardar enteramente por espacio de largos períodos es muy importante, ya que permite al fitotecnista hibridar especies que florecen normalmente en diferentes épocas". Este es un objetivo más de la conservación del polen. También King (3) expresa, que el propósit particular en sus pruebas de almacenamiento del polen de papa ha sido determinar las características de longevidad del polen de estación a estación, y si es posible contribuir a que el almacenamiento de polen pueda ser rutina para los técnicos reproductores de papa, cuando se necesite.

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* Contribución de la Estación Experimental Tropical de Pichilingue sostenida por el Servicio Cooperativo Interamericano de Agricultura mediante un convenio especial entre los Estados Unidos y el Ecuador.

** Estudiante egresado. Becado por el American Cocoa Research Institute, Washington, D.C.

*** Consejero de Investigaciones en Horticultura, USOM/Ecuador

Griggs (2) indica, que los estudios que se refieren al almacenamiento del polen generalmente han considerado la relación existente entre la longevidad y viabilidad del polen sometido a diversas temperaturas y humedades relativas, o la combinación de estos factores.

El polen generalmente ha sido almacenado en un rango muy amplio de temperaturas desde el medio ambiente hasta menos 56ºC (hielo seco). La humedad relativa ha sido controlada con agentes tales como ácido sulfúrico (SO_4H_2) y cloruro de calcio (Cl_2Ca).

King (3) en 1955 informa, que los estudios sobre la longevidad del polen en los últimos 40 años han considerado lo siguiente: temperatura y/o humedad, variación en la presión, medios de cultivo y condiciones fisiológicas.

Investigaciones conducidas en Turrialba (1), indican que el polen de cacao tiene una corta viabilidad, de 2 a 3 días en estado natural. Con el objeto de probar la viabilidad del polen hasta 15 días de almacenado, se condujeron experimentos bajo refrigeración a 9ºC, 4ºC, 0ºC y menos 6ºC, utilizando bolsas de papel glacine y de polietileno. Se observó una elongación inicial del tubo polínico en un 20% de las muestras sometidas a 4º y 8ºC en bolsas de polietileno por 2 ó 3 días.

En este trabajo se presentan los resultados encontrados en dos ensayos sobre conservación y almacenamiento del polen de cacao en flores y botones, usando varios métodos de almacenaje, diferentes temperaturas y humedades relativas. Las investigaciones que se condujeron tienen el carácter de exploratorias, para la realización de futuros ensayos de almacenaje de polen a espacios mayores de tiempo.

MATERIALES Y METODOS

Los tratamientos usados para el almacenaje y conservación del polen de cacao en flores y botones, se describen a continuación:

Experimento Nº 1

1. Flores con pedúnculo en agua
2. Botones con pedúnculo en agua
3. Ramitas con flores en agua
4. Ramitas con botones en agua
5. Flores en tubos con cloruro de calcio y 25ºC

6. Botones en tubos con cloruro de calcio y 25ºC
7. Flores en tubos con cloruro de calcio y 5ºC
8. Botones en tubos con cloruro de calcio y 5ºC
9. Flores en tubos con cloruro de calcio y -20ºC
10. Botones en tubos con cloruro de calcio y -20ºC.

Experimento Nº 2

1. Botones con pedúnculo en agua
2. Botones en tubos con cloruro de calcio y 25ºC
3. Flores en tubos con cloruro de calcio y 5ºC
4. Flores en tubos con algodón y -20ºC.

Las flores almacenadas estaban recién abiertas y los botones próximos a abrir. En los dos primeros tratamientos, se usaron cajas de petri con agua en sus tres cuartas partes, y se colocó un papel (tipo bond para que no se embeba muy rápido) con agujeros, en donde se introdujeron los pedúnculos.

En los tratamientos 3 y 4 se utilizaron ramitas con diámetros de 1 cm. más o menos, las que contenían botones y flores según el tratamiento, y se colocaron en un recipiente con agua, sumergiendo el extremo inferior de la ramita. Estos tratamientos se hicieron en un laboratorio con temperatura media de 25ºC a la sombra.

Se usaron tubos de vidrio de 2 cm. de diámetro, con cloruro de calcio hasta una cuarta parte y un pedazo de algodón; los tubos se taparon con un corcho. Las temperaturas de 5ºC y menos 20ºC se obtuvieron en una refrigeradora y en un congelador respectivamente.

El cloruro de calcio (Cl_2Ca) por ser una sustancia higroscópica, baja notablemente la humedad relativa del aire contenido en el espacio vacío del tubo, donde se alojan las flores o botones. El contenido del tubo queda prácticamente seco (4). Este factor y la baja temperatura, o su combinación, son deseables en el problema que nos ocupa (3).

En las polinizaciones realizadas para comprobar la viabilidad del polen conservado en los diferentes medios de almacenaje, se usó como madre el clon EET 162; y el método de polinización indicado por Pound (5).

La variación por compatibilidad cruzada puede ser reducida, usando un mismo cruce: EET 162 x SCA 6. Se comprobó en un ensayo aparte, que no había variación estadísticamente significativa, polinizando en cualquiera de las horas laborables; por lo tanto se polinizó en las tardes cuando fue necesario. Se tuvo la precaución de no polinizar al momento de lluvia. Los tubos de vidrio usados en las polinizaciones artificiales se sujetaron a la rama con alambre liso fino, además de plastilina; así se eliminó la

caída de tubos que ocurre frecuentemente.

El diseño estadístico usado fue el de parcelas sub-divididas, con cuatro repeticiones. Se hicieron cinco polinizaciones por repetición en días o en semanas diferentes; de esta manera quedó desvirtuado un efecto ambiental en los porcentajes de cuajamiento que se presentan en los cuadros.

RESULTADOS

Se condujo un ensayo con el objeto de observar el comportamiento del polen de cacao en diversos tratamientos de conservación. Los promedios de cuajamiento registrados en los diversos tratamientos de conservación por un período de tres días, se presentan a continuación. Como referencia comparativa para estos promedios se efectuó el mismo cruce usado en los dos ensayos, mediante polinización controlada con flores sin almacenar, y se obtuvo el 67.5% de cuajamiento de 160 polinizaciones realizadas en días y horas diferentes.

Cuadro Nº 1. Diversos tratamientos de conservación del polen de cacao

Promedios de cuajamiento de cinco polinizaciones repetidas cuatro veces. Noviembre 9, 1959

Tratamientos	Días			Promedio	Cuajamiento
	1	2	3		
1. Flores con pedúnculo en agua	3.50	2.75	1.75	2.66	53.2%
2. Botones con pedúnculo en agua	3.75	1.25	2.50	2.50	50.0
3. Ramitas con flores, en agua	2.50	2.75	1.75	2.33	46.6
4. Ramitas con botones, en agua	3.25	3.25	2.75	3.08	61.6
5. Flores en tubos con Cl_2Ca y 25ºC	3.25	1.25	1.25	1.91	38.2
6. Botones en tubos con Cl_2Ca y 25ºC	2.50	0.75	3.00	2.08	41.6
7. Flores en tubos con Cl_2Ca y 5ºC	3.00	2.75	4.00	3.25	65.0
8. Botones en tubos con Cl_2Ca y 5ºC	0.75	0.75	0.25	0.58	11.6
9. Flores en tubos con Cl_2Ca y -20ºC	2.75	0.25	1.50	1.50	30.0
10. Botones en tubos con Cl_2Ca y -20ºC	0.25	0.25	0.00	0.16	3.2
Promedio (1)	2.55	1.60	1.87		
DLS 5%				0.96	
DLS 1%				1.29	

DLS 5% (1) 0.61
DLS 1% 0.81

No se encontró diferencia significativa en los cuatro prim
tratamientos; pero se piensa que el tratamiento de botones con
dúnculo en agua puede mantener su polen viable un tiempo más la
por cuanto sus botones abrieron al siguiente día de sumergidos
pedúnculos en agua; esto lo pone en ventaja sobre los otros tre
con 1 ó 2 días.

En los tratamientos con temperatura ambiente, o sea 25ºC,
puede notar un efecto favorable de la temperatura en el normal
sarrollo fisiológico del polen en los botones, que se traduce e
mejor promedio a los tres días; el promedio bajo del segundo dí
es explicable, y para el efecto se harán nuevas pruebas.

En los tratamientos de 5ºC, se nota un efecto favorable en
polen de las flores, contrariamente a la temperatura anterior,
plicándose que la humedad relativa en los tubos al sufrir un de
mento por el factor baja temperatura, no favoreció al polen de
botones, pero sí al de las flores.

En los tratamientos con temperatura de -20ºC se aprecia in
rioridad con respecto a los anteriores; podría explicarse análo
mente como un efecto desventajoso de la temperatura aun más ba
que aumenta el decremento de la humedad relativa dentro de los
bos.

Los resultados anteriormente expuestos, han motivado un n
ensayo, observando la viabilidad por siete días. Se seleccion
los tres mejores tratamientos; incluyendo también al de flores
tubos y -20ºC, pero sin cloruro de calcio.

Analizados los datos que se presentan en el cuadro Nº 2,
se encontró diferencia significativa para los tratamientos. A
pados en una clase los tratamientos con temperatura baja y con
res, y en otra clase los tratamientos con temperatura ambiente
(25ºC) y con botones, si se encontró significación estadística
nivel del 1%, como se puede apreciar en el cuadro que se prese
a continuación.

Cuadro Nº 2. Efecto de diferentes tratamientos en la conservación de flores y botones de cacao expresado en porcentaje de cuajamiento. Enero 6, 1960

Número días	Promedio de dos tratamientos: Flores en tubos con Cl_2Ca, algodón y 5ºC. Sin Cl_2Ca y -20ºC	Promedio de dos tratamientos: Botones en tubos con Cl_2Ca, algodón y 25ºC. Botones con pedúnculo en agua y 25ºC	Promedio de días, sobre 5 polinizaciones	Promedio de días en porcentaje
1	65.0%	58.0%	3.00	60.0%
2	50.0	52.5	2.56	51.2
3	30.0	15.0	1.12	22.4
4	50.0	32.5	2.06	41.2
5	50.0	30.0	2.00	40.0
6	37.5	25.0	1.56	31.2
7	50.0	25.0	1.87	37.5
Promedio	47.5[xx]	33.6		
DLS 5%			0.77	
DLS 1%			1.02	

[xx] Excede el nivel de significación al 1%.

CONCLUSION

Los mejores tratamientos de almacenaje y conservación de po de cacao en el presente trabajo son:

1. Flores en tubos con cloruro de calcio (Cl_2Ca) y 5ºC que dan 50% de cuajamiento después de siete días.
2. Flores en tubos con algodón y -20ºC también con 50% de cuajamiento después de siete días.
3. Botones con pedúnculo sumergido en agua, con 50% de cua miento a los tres días de almacenado y 35% a los cuatro días.

Los dos primeros tratamientos se les podría usar para trans- porte en tiempo más largo, y el último para distancias cortas en casos particulares.

RESUMEN

Se llevaron a cabo dos experimentos para determinar por cuanto tiempo el polen de cacao podía permanecer viable bajo almacenaje.

Cuando se almacenó flores en tubos tapados con cloruro de calcio a 5ºC, se obtuvo un 50% de cuajamiento con polen almacenado 7 días. Se obtuvo también 50% de cuajamiento con polen almacenado por 7 días en tubos tapados con algodón y a -20ºC.

SUMMARY

Two experiments were conducted to determine how long cacao pollen would remain viable under different storage environments.

When cacao flowers were stored in sealed tubes with calcium chloride at 5ºC it was possible to obtain a 50% fruit set with pollen stored seven days. It was also possible to obtain a 50% fruit set with pollen stored seven days in sealed tubes with cott at -20ºC.

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SUMMARY OF DISCUSSION

r. J. Soria V. (IAIAS)

I found in 1959 that the low temperature treatments suggested n the paper did not help in maintaining the viability of pollen. erhaps this was because we were conserving complete flowers and ll their fleshy parts. Later, I carried out other experiments lacing the flowers in test tubes with calcium chloride and using emperatures as low as minus 30°C. over a period. We could con-erve pollen for periods varying from 8 days to 1 month. This in-icates that it is possible to conserve pollen a' low temperatures, roviding it is done at low relative humidity.

AUXINS OF CACAO AND CHERELLE WILT

R. Nichols[*]

Cherelle Wilt, the shrivelling and blackening of young cocoa pods, may account for an appreciable depression in the potential yield of a cocoa tree. The figures of Pyke (1933) illustrate the variation between trees with regard to the incidence of Cherelle Wilt, ranging from a loss of 92.5 per cent of young pods on some trees to 19 per cent on others. However, this does not mean that in the complete absence of Cherelle Wilt that the crop would be increased by these percentages; clearly it is a physiological impossibility for a normal cacao tree to carry through to maturity all the flowers set and in terms of a practical approach to the problem this point should be fully realised. It follows that Cherelle Wilt is an intrinsic phenomenon, the end result of which is the maturation of a certain number of pods at the expense of others, the actual relative percentages being peculiar to the physiological status of the tree. It is therefore a reasonable hypothesis to regard Cherelle Wilt as a physiological thinning mechanism, just as much a part of the overall growth phenomena of cacao as "flushing" or leaf abscission.

The object of this current study has been to determine whether the endogenous growth substances of the developing pods vary with the observed "waves" of wilting and how Wilt is initiated. If a correlation between Auxins and Wilt was shown, experimentation on the use of synthetic growth regulators for the control of Wilt would be justified. In this sense control implies a reduction of Wilt rather than its complete elimination. In order to clarify this hypothesis it is easier to consider the fate of one individual pod and those factors which may determine the predisposition of this pod to wilt. Assuming normal fertilisation has taken place, the fate of the pod will depend on a number of factors:-

(1) Nutrient supply
(2) Water supply
(3) Endogenous factors peculiar to the pod
(4) Freedom from mechanical damage
(5) Microbial infection or biotic damage.

I intend to consider only the first three factors because these may be shown to be associated with Wilt phenomena and later to consider factor four as a possible contributory factor.

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[*] Regional Research Centre, Imperial College of Tropical Agriculture.

There can be little doubt that nutrient supply must erforce be important to the pod and there is considerable vidence to support this statement. The simplest and most onclusive evidence is that one way of ensuring that the pod ill survive beyond the stage at which it will not be subject o physiological Wilt, is to remove all other competitive pods rom the tree and to a limited degree this is used in the prac- ice of carrying out controlled pollination. What is not nown however, is the maximal number of pods a particular tree ill carry without inducing Cherelle Wilt. The heavy Wilt hich follows flushing may also suggest that competition for utrients between the young flushes and the developing pods is t least a partly contributory factor.

The effect of water supply to the pod cannot be clearly eparable from the effect of nutrients but it is of interest to ote that wilting is equally prevalent in the wet season, when t may be tacitly assumed that the tree as a whole is not under water stress. This does not preclude that any one pod may ot be under such a stress owing to its intrinsic vascular evelopment and following from this, a consideration of the third actor, endogenous factors peculiar to the pod, may be made.

The expression "endogenous factors" of the pod is used to over a lack of specific knowledge but certain features of the pod ill endow it with a competitive advantage over its neighbours. onsidering two pods only on a tree, if factors 1 and 2 are not imiting then the endogenous auxins may determine which pod will each maturity by exerting their influence on vascular development, od wall growth etc. Clearly with only two pods to consider both ay stand an equal chance of reaching maturity but as more and ore pods are set so there must come a critical stage in the num- er of pods on the tree above which Wilt may occur through a sub- ptimal supply of nutrients or water. It is considered that at his stage the endogenous factors may determine the ultimate fate f the pod by increasing the nutrient flow to the pod conferring pon it a competitive advantage over its neighbours.

The first stage of the problem has been to examine whether here exists in the life history of a pod a predisposition to wilt. t is fairly clearly established that after a pod reaches 10 cms. n length or say 70-100 days from fertilisation it is unlikely to e lost by physiological Wilt, that is some physiological stage as been reached which has predetermined the fate of the pod. It ay be conjectured that vascular organisation has been completed.

Prior to this stage it has been shown by McKelvie (1956) and by Akinbode (1958) that the predisposition of pods to wilt is a discontinuous process in that at 5-6 weeks from pollination a pod is more likely to wilt than at any other time in its history. McKelvie finds two peaks of wilting and Akinbode one but in essence the results are similar. A discontinuous pattern of this type would suggest that auxins may be responsible for the control of the developing pods and the nature of these auxins has been investigated.

A preliminary survey of the auxins of cacao was carried out and a brief report of this work was published (Nichols, 1957). Briefly three growth substances were found, two acidic and one neutral in behaviour. One of the acid substances behaved similarly in chromatographic investigations to indolyl acetic acid, a commonly occurring native growth substance, but in the absence of positive identification it was named Cacao Auxin I. Following this procedure, the neutral growth promoting substance was named Cacao Auxin II. The other acidic substance was a growth inhibitor, found consistently in all types of cacao tissue examined e.g. cherelles, flush leaves etc. and a hypothesis was advanced that the phenomenon of Cherelle Wilt could be explained by assuming that the inhibitor if readily translocated from flushes or pods could inhibit further pod growth. It was shown that the inhibitor could inhibit cell elongation of wheat coleoptiles and that the inhibition was reversible indicating that the inhibitor was not merely acting as a toxic substance. Further development of this hypothesis would demand an identification of the compound or complex; the indications at present are that the inhibitor is a complex of phenolic acids.

A rough quantitative relationship was established between Cacao Auxin I and pod development, but it awaited the use of the oat curvature test before small quantities of tissue could be used for a quantitative examination of Auxin I and II in the cherelles. An inverse relationship between the wilt index and the endogenous auxins of young cherelles was established (Nichols, 1959) i.e. free auxins were not readily extractable when the pods were likely to wilt. This was important as it was the first evidence that Wilt and the endogenous auxins were correlated and therefore that control by synthetic growth regulators might be practicable.

One of the stumbling blocks in any comprehensive understandin of the problem of Wilt is that the causal mechanism of Wilt i.e. the physical expression, is unknown. In many fruits the comparable mechanism is the formation of an abscission layer which effectively seals the fruit from the parent tree. The abscission layer found at

he base of the flower stalk of cacao does not become functional nce fertilisation has taken place. Unfertilised flowers and elaminated leaves will abscise but not fruits. It is therefore ecessary to look for some other mechanism which may effect the hysical expression of Wilt and this has entailed an anatomical xamination of cacao fruits.

The general anatomy of the vegetative parts of cacao has een investigated by Brooks and Guard (1951) but no attention was aid to the fruits. In our investigations the preliminary exami- ation was carried out by mounting pods of various ages by means f their peduncles on manometers filled with basic fuchsin and pplying through a manifold a gas pressure of 5 lbs. per square nch. Within six to eight hours the internal vascular skeleton f the pods is heavily stained and may be examined by macroscopic ransverse sections - see fig. I.

Briefly, it can be shown that there are five vascular undles running centrally through the length of the pod from which ateral bundles are given off to the ovules. External to the ovules re five discrete bundles radial to the central bundles and these lso run longitudinally, joining with the central bundles at the asipetal end of the pod. However, between the pod wall and the vules a distinct pentagonal tissue can be seen macroscopically, tissue which stains heavily with fuchsin on its inner side. his stained tissue is composed of an indeterminate number of small ascular bundles. The pentagonal layer of tissue is an actively ividing cambium presumably responsible for cell divisions which ncrease the size of the pod both in length and girth. The pecu- iar feature however is that the pod wall appears to be primarily erved by radial bundles contiguous with the small bundles adja- ent to the cambial layer but the wall itself does not appear to e served with permanent longitudinal bundles of its own. If this s in fact a correct interpretation of the vascular system then a isturbance or a disruption of the cambial layer and the adjacent undles will result in a drying of the pod wall. One of the undamental differences between a healthy pod and a pod displaying ncipient Wilt is that the cambial layer and tissues internally djacent to it in a healthy pod exhibit oxidative browning after few minutes exposure to air whereas in the pod showing incipient ilt the oxidation has already occurred. The suggestion is that cclusion of the vascular elements of the tissue adjacent to the ambial layer initiates the wilting process. If this were the ase then it may be expected that injection experiments with fuch- in would reveal differences between healthy and wilting pods and

this has been shown to be the case. Healthy pods will permit a ready uptake of fuchsin whereas a pod showing late Wilt will accept little or none. Moreover, a pod which by cessation of increase in length can be shown to be in the early stage of Wilt, although showing little or no external symptoms will take up fuchsin, appreciably less though than the healthy pod. The inference is that the xylem is occluded in some way. To date only transverse sections of the pod-stalks from healthy and late Wilt pods have been examined microscopically and in some detail but the preliminary investigations have revealed bodies which stain heavily with safranin located in the lumens of the vessels of the late Wilt pod-stalks. These stained bodies are absent from the vessels of healthy pod-stalks. The nature of these occlusions is unknown but their appearance suggest that they are chemical obstructions and not tyloses.

In essence the preliminary data indicate that an occlusion of the vascular tissue is responsible for the drying out, or the physical expression of Wilt - this does not however answer the question of what initiates the chemical obstruction. Only a tentative hypothesis may be put forward but my view is that the endogenous auxins may control or play some part in the organisation of the cambial layer in the pod wall which in turn affects the vascular tissue and that all further expressions of Wilt are secondary. A summary of the hypothetical interactions of auxins and nutrients on fruit development is presented in fig. II.

Returning to the examination of an individual pod, if either nutrients or auxins are limiting Wilt will occur. Both types of compound will be to some extent interdependent and therefore chemical control of Wilt is only likely to be of value on pods for which nutrients may be just limiting i.e. nutrient supply to the pods may be stepped-up by synthetic compounds analogous to auxins. Clearly chemical additives will be only of value over a limited period i.e. just before incipient Wilt commences, but not after Wilt has commenced or long before it has started; Akinbode (op. cit.) has some evidence for this view.

The work of Miller (1954) in which he shows that mechanical stimuli may induce wilting of young pods is of considerable interest and not incompatible with the above concept of the mechanism of Wilt. External mechanical abrasion of the pod may be expected to cause internal disruption of cells with a concomitant liberation of polyphenol oxidase, an enzyme which has been shown to inactivate indolyl acetic acid (Berducou, 1958). In young cacao pods the cambial layer a tissue highly active with respect to polyphenol oxidase, is quite near the pod surface; bruising or mechanical damage of the wall may therefore readily affect the cambial layer through the medium of this same polyphenol oxidase enzyme.

Fig. I

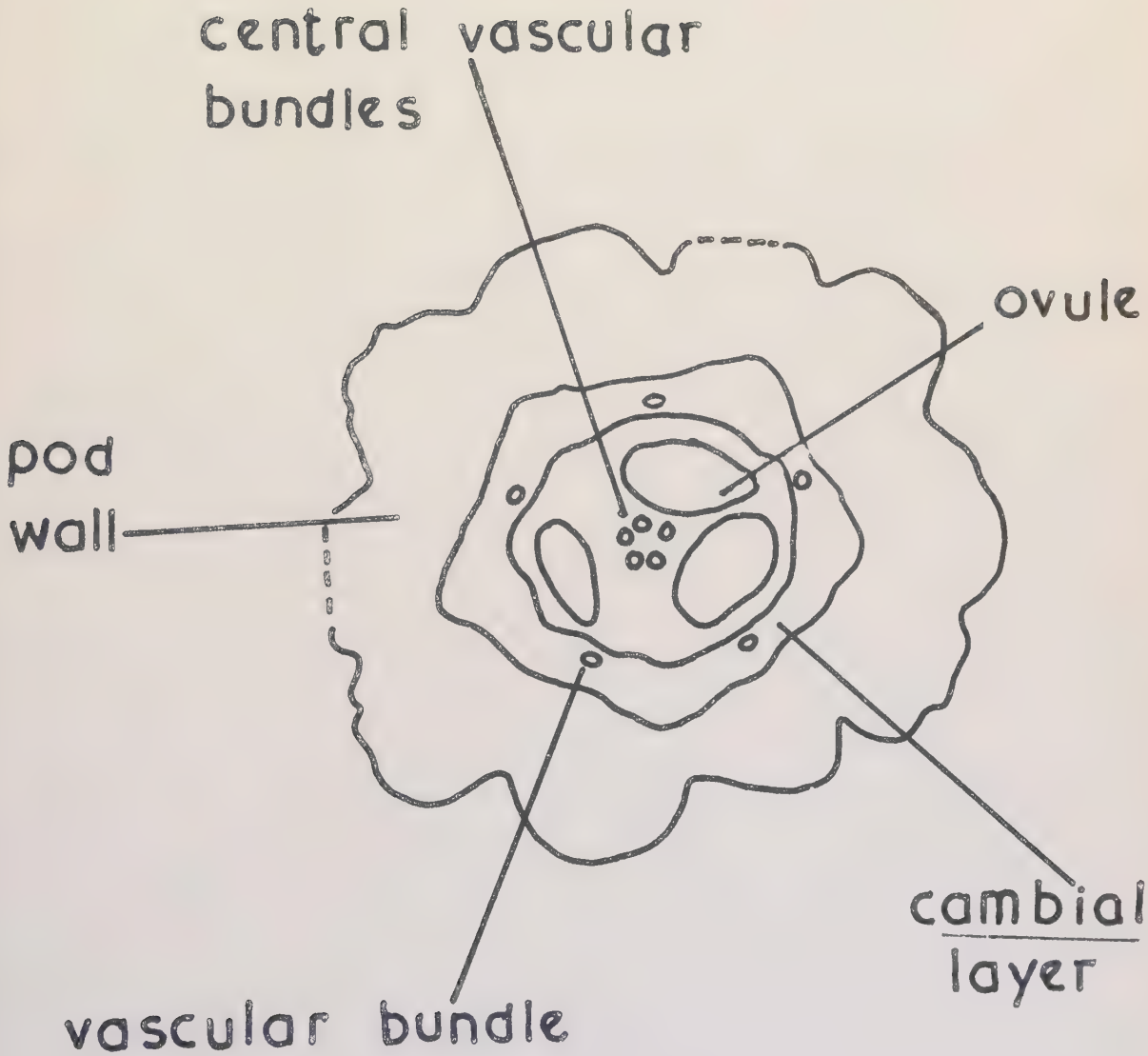
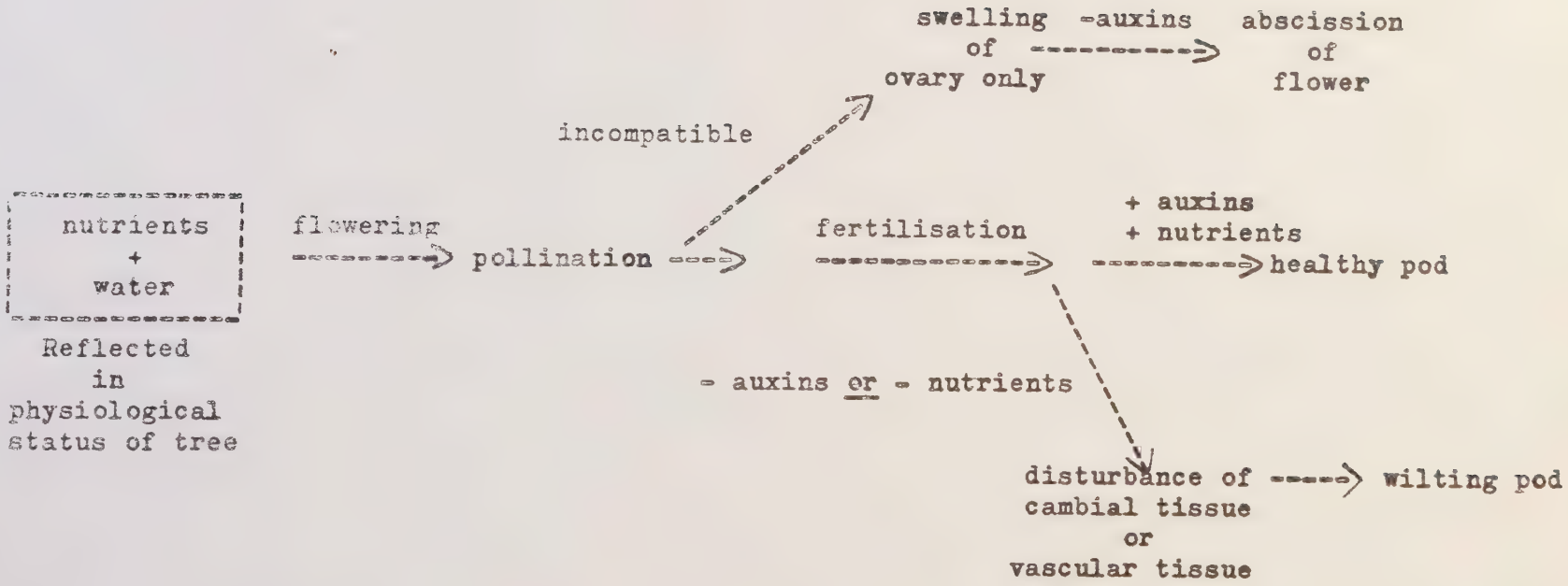


Fig. I Simplified and diagramatic transverse section of cacao pod, 8 cms long, injected with fuchsin and cut 2 cms from basipetal end of pod.

Figure II.


swelling of ovary only
-auxins
abscission of flower
incompatible
nutrients + water
flowering
pollination
fertilisation
+ auxins
+ nutrients
healthy pod
Reflected in physiological status of tree
- auxins or - nutrients
disturbance of cambial tissue or vascular tissue
wilting pod

SUMMARY

Cherelle Wilt may be regarded as a physiological thinning process. The object of the author's studies is to determine whether there is a correlation between the endogenous growth substances (auxins) and wilt; if so, experimentation with synthetic growth substances for the control of wilt would be justified.

Three growth substances were detected in cacao, and an inverse relationship between wilt index and the endogenous auxins was established. The mechanism of wilt was studied. It is not caused by the formation of an abscission layer. The preliminary data indicate that an occlusion of the vascular tissue adjacent to the cambial layer initiates wilt, and the hypothesis advances is that thus it may be controlled by the endogenous auxins.

RESUMEN

El marchitamiento prematuro de los frutos puede ser considerado como un proceso fisiológico de raleo. El objeto de este estudio es desterminar si hay correlación entre las sustancias de crecimiento endógeno (auxinas) y el marchitamiento de frutos; si esto es así, se justificaría realizar experimentos con sustancias de crecimiento sintéticas para controlar el crecimiento y el marchitamiento.

Se encontraron tres tipos de sustancias de crecimiento en cacao y se estableció una relación inversa entre el índice de marchitamiento y las auxinas endógenas. Se estudió el mecanísmo del marchitamiento. No es causado por la formación de una zona de abscisión. Los datos preliminares indican que una oclusión de los tejidos vasculares, adyacentes al cambium, provoca el marchitamiento y se propusó la hipótesis de que ésto es controlado por auxinas endógenas.

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SUMMARY OF DISCUSSION

r. C.S. Navarrete (Venezuela)

Have you been able to determine the chemical nature of the nhibitor referred to in the paper?

r. D.B. Murray (ICTA)

We do not have a technique of identifying precisely the sub-tances referred to. All we can say is that we have obtained ifferences when put on to chromatograms.

r. D.R. Glendinning (WACRI)

At WACRI, where Cherelle Wilt is usually about 80%, addi-ional pollinations resulted in greater wilt, and reducing of ets by removing a proportion reduced the proportion of wilt, either treatment affecting final yield. It seems, therefore, hat wilt operates to reduce the number of pods to that which the ree can carry, and that natural pollination is about five times hat is required.

It is clear that the position in Peru, as reported by Sr. Hur-ado, is entirely different from that in West Africa. It would eem that pollination, or at least cross-pollination, is normally nadequate there. In such conditions, any wilt which occurred ould constitute wastage of pods.

I would like to make the general point that it is dangerous o refer the results of work in one part of the world to conditions n another part without careful checking. The present case, in hich it appears there is a difference in the pollination situation, alls for caution in regard to (1) assessing the importance of Che-elle Wilt and the value of attempts to control it; (2) the use of nsecticides, and (3) the design of seed gardens for producing hy-rid seed.

The insects primarily concerned in cross-pollination in West frica are certain small midges which are protected in the larval tage by living in trash where the insecticides cannot reach them, o that although insecticides destroy the flying adult population, hey are rapidly replaced. It is also known though that various rawling insects are concerned in pollination, self pollinating lowers which they happen to enter. The importance of such insects,

relative to that of the flying insects, may vary in different parts of the world, and their populations may be more readily damaged by insecticides than those of the midges.

The relative productivity of self-compatible and self-incompatible cocoa varieties may also be influenced by differences in the relative abundance of the different types of insects concerned in pollination.

Mr. G. Havord (IAIAS)

In Costa Rica preliminary results from a field experiment in which trees are hand pollinated under different insecticide treatments indicate that there was no appreciable increase in total yield, but a tendency for increased wilt of other fruits on the tree. Here 10 additional flowers were pollinated each week; we are now going to try massive pollinations at the time when the peak crop normally sets.

ECTOS DE LA POLINIZACION CONTROLADA SOBRE LA PRODUCCION DEL CACAO

C. A. Hurtado*

INTRODUCCION

Se sabe que las pequeñas moscas Forcipomyia sp. de la familia ratopogonidae son aparentemente los principales agentes polinizares de las flores del cacao (1, 3, y 4). Según Posnette y Entwistle) esas moscas siempre están presente en suficiente cantidad para ectuar una adecuada polinización. Sin embargo, cuando existe el oblema de la autoincompatibilidad, fenómeno muy comun principalnte entre las selecciones del cacao "Forastero" del Alto Amazonas polinización puede ser incompleta o dificiente, contribuyendo problemente a reducir el rendimiento potencial de la planta.

Algunos de los clones con que se trabaja en el Perú son del tipo toincompatible. Entre esos ha merecido especial atención por su sistencia a la Escoba de Bruja los seleccionados por Pound, conodos en el País como clones "Pound", de los cuales los más imporntes son Pound 7 y 12. Uno de los objetivos del presente estudio sido él de determinar la influencia que puede tener la polinizaón controlada sobre la capacidad productiva de esos clones. Asi smo se ha buscado obtener algunas informaciones sobre la influencia la polinización controlada en algunas características de la mazor, como dimensiones, peso, número de semillas, etc. según observaones hechas en varios clones que se cultivan en la Estación Experintal de Tingo Maria.

MATERIALES Y METODOS

El presente trabajo ha sido realizado en la Estación Experimenl de Tingo Maria, utilizando arboles clonales de 8 y 9 años de ad en condiciones normales de cultivo.

Para la polinización controlada: Se utilizó una técnica simplicada, la cual difiere del método tradicional propuesto por Voelcker Pound (2 y 5) por el hecho de emplear bolsitas de polietileno en gar de cilindros de vidrio. Dichas bolsas, 4.5 cm de ancho por 0 cm de largo, adheridas por un extremo a una rodaja de plasticina e sirve para fijar la bolsita en la rama. El otro extremo es liramente cubierto con algodón y fijado con una grampita lo que perte el fácil intercambio gaseoso y a la vez como medio aislante de s insectos.

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efe del Departamento de Cacao y Arboricultura, Estación Experiental Agrícola, Tingo Maria, Perú.

La bolsa de polietileno permite adaptarse más fácilmente a cua quier rama por delgada que sea, aprovechando de esta manera el mayo número de flores. (Foto 1,2)

El procedimiento para la polinización contralada se reduce a l siguiente faces:

a) aislamiento de las flores en la tarde del día anterior, usando botones florales casi por abrirse;

b) castración de la flor receptora del polen en la planta madre en la mañana siguiente, dejando los sépalos y el estigma floral completamente libre;

c) frotamiento de las anteras de la flor portadora de polen sobre el estigma;

d) aislamiento de la flor polinizada mediante la bolsa de polietileno por espacio de 24 horas.

Para estudiar el efecto de la polinización controlada sobre la producción de los arboles de cacao, se seleccionaron 28 plantas uni formes de 9 años de edad del clon Pound-12. De estas plantas, 14 fueron polinizadas frecuentemente, con polen del clon ICS-1 y mien- tras que 14 permanecieron como testigo de polinización abierta. La polinización se efectuó según la disponibilidad de flores, haciendo en promedio de 4 a 6 polinizaciones por árbol por día, durante 15 días y aprovechando una época de mayor floración (enero-febrero).

RESULTADOS

Los resultados obtenidos mostramos a continuación

Tabla 1 Compatibilidad entre algunos clones cultivados en el Perú según el porcentaje de cuajamiento en cruzamientos y auto polinizaciones. 1958-1959

Clones Madres		Clones Padres	Número de Polinizaciones	Porcentaje de Cuajamiento
P-7	x	UF-613	150	78.0
P-7	x	ICS-1	180	81.5
P-12	x	P-7	500	9.8
P-12	x	P-12	500	5.6
P-12	x	UF-676	100	62.0
P-32	x	UF-613	120	65.0

ontinuación Tabla 1

Clones Madres		Clones Padres	Número de Polinizaciones	Porcentaje de Cuajamiento
SCA-6	x	UF-613	200	63.5
SCA-6	x	UF-650	300	66.0
SCA-6	x	ICS-1	300	70.0
SCA-12	x	ICS-1	210	70.0
UF-2	x	P-19	49	60.9
UF-613	x	P-7	160	82.5
UF-613	x	SCA-6	200	72.5
ICS-1	x	P-7	250	78.0
ICS-1	x	P-16	100	65.0
ICS-39	x	SCA-12	272	73.5

Un bajo porcentaje de cuajamiento arrojó el cruce entre plan-as del mismo clon Pound-12, aunque el cuajamiento de flores aumen-ó ligeramente cuando se cruzó con el clon Pound-7.

Se observa que el mayor porcentaje de cuajamiento corresponde los cruzamientos del clon Pound-7, con los clones ICS-1 y UF-613 sus respectivos cruces inversos; esto puede ser posible dado al ran vigor que manifiestan los respectivos árboles.

Los porcentajes de cuajamiento de los clones SCA-6 con los lones Trinitarios, aunque no son bajos en promedio, resultan meno-es que los de los cruces Pound Trinitario y vice versa; esto puede er en parte debido al poco vigor de los árboles, característica anifestada por los árboles de los clones SCA-6 y SCA-12, en la zo-a de Tingo Maria.

abla 2 Efecto de la polinización controlada sobre algunas características del fruto y de la semilla: Promedio de 30 mazorcas

	FRUTO				SEMILLA		
	Peso Gr	Largo cm	Diamet cm	Espesor Casc mm	Nº Prom semillas	Peso Total Prom x Frut	Peso Prom x Semilla
ound-7 (Pol Ab)	507.3	15.4	7.7	10.2	35	112.0	3.2
" xUF 613	697.6	17.8	8.3	10.1	49	182.3	3.7
" x ICS-1	637.4	18.0	8.3	10.2	49	160.0	3.3
ound-12(Pol Ab)	409.4	15.9	7.7	9.5	28	91.0	3.2
" x UF-676	480.7	16.5	7.4	8.4	36	111.0	3.4

Continuación Tabla 2

	FRUTO				SEMILLA		
	Peso Gr	Largo cm	Diamet cm	Espesor Casc mm	Nº Prom semillas	Peso Total Prom x Frut	Peso Prom x semilla
Pound-32(Pol Ab)	446.1	15.0	7.2	8.3	25	81.0	3.2
" x UF-613	505.0	15.9	7.6	8.2	41	139.0	3.3
SCA-6 (Pol Abt)	312.3	16.4	7.5	8.1	36	104.4	2.9
SCA-6 x UF-613	317.6	15.1	6.5	6.4	40	108.0	2.7
SCA-6 x ICS-1	359.1	15.3	6.4	7.2	41	129.4	3.1
SCA-6 x UF-650	376.8	16.4	7.3	6.2	27	103.3	3.8
UF-613 (Pol Abt)	512.4	16.0	8.5	9.5	38	127.1	4.1
UF-613 x P-7	527.3	15.6	7.5	9.0	43	150.7	3.5
UF-613 x SCA-6	596.6	17.7	9.8	11.1	37	136.8	3.6
ICS-1 (Pol Abt)	591.0	19.3	9.8	10.8	34	138.3	4.1
ICS-1 x P-7	695.2	18.8	9.2	11.1	41	184.3	4.3
ICS-1 x P-16	763.0	19.7	9.8	12.2	40	184.5	4.6
SCA-12 (Pol Abt)	413.6	14.3	6.9	10.2	36	109.8	3.0
SCA-12 x ICS-1	432.3	15.4	6.9	10.2	36	116.8	3.2
ICS-39 (Pol Abt)	546.2	17.7	7.2	11.4	31	142.6	4.6
ICS-39 x SCA-12	590.0	19.3	7.6	10.6	35	164.5	4.7

Se puede observar un aumento de peso total del fruto, en los diferentes cruzamientos realizados, en comparación con los frutos formados por polinización abierta.

Aparentemente no hay influencia en el largo, diámetro y espesor de la cáscara del fruto, aunque en esta última hay una tendencia de ligera disminución de espesór en los frutos polinizados.

Tabla 3 **Número de frutos hasta cinco meses de edad, actualmente en crecimiento en árboles de polinización abierta y controlada. Clon Pound-12**

Polinización Abierta	Polinización Controlada
4	70
15	14
13	50
34	31
13	21
25	40
28	49

Bolsita de polietileno en la polinizacion
de un arbol de cacao

Conjunto de bolsitas de polietileno durante
la polinizacion controlada

Arbol de cacao mostrando gran numero de frutos por efecto de la polinizacion controlada (Clon Pound–12)

Arbol del clon pound–12 mostrando gran numero de frutos por efecto de la polinizacion controlada

ontinuación Tabla 3

Polinización Abierta	Polinización Controlada
9	82
32	47
6	38
22	32
25	162
7	52
17	17
Total 250	705
Prom. x Pta 17.8	50.3
Aumento en Porcentaje por efecto de-Polinización controlada....282% +	

La diferencia es altamente significativa a favor de los frutos ormados por polinización controlada. (Foto 3, 4. Arboles mostrando os frutos)

DISCUSION Y CONCLUSIONES

De las observaciones realizadas se desprende las siguientes con-lusiones.

Existe una manifiesta autoincompatibilidad del clon Pound-12, si como una clara evidencia de la incompatibilidad del clon ound-7, por los bajos porcentajes de cuajamiento conseguidos.

Es posible conseguir mejor polinización en los clones Pound de ndimiento limitado, mediante el cruzamiento libre con aquellos que esentan mayor afinidad, tales como los clones UF-613 e ICS-1, por dio de plantaciones intercaladas.

Existe marcada influencia en el aumento de peso total del fru-, aunque no podemos afirmar que exista efecto en longitud, diáme-o y espesor de la cáscara, tendiendo esta última a disminuir. Sin bargo podemos decir que estas características dependerían de las e poseen los clones que se cruzan.

Diferencia altamente significativa

El número de semillas aumentó considerablemente, lo que prueba evidentemente el efecto de la polinización controlada sobre aumento en número de semillas. Razones fundamentales pueden ser: cantidad de granos de pólen depositados en el estigma floral y gran compatibilidad entre los clones cruzados.

Positivamente no podemos evidenciar la influencia que existe sobre el aumento en el peso promedio de las semillas.

Consecuentemente, el aumento en número de semillas por fruto justifica el aumento de peso total de las semillas y del fruto mismo el que puede ser más compacto y lleno.

Quedó demostrado que hay influencia marcada en la producción de los árboles de cacao, polinizados en forma controlada, debido al gran aumento obtenido en el número de frutos. Esto último por lo menos se acepta en el caso de los clones Pound que se muestran como plantas incompatibles.

Un estudio amplio se puede recomendar, incluyendo en él, clones autocompatibles para observar los efectos de la polinización controlada en este tipo de árboles, pués los datos referidos en el presente trabajo se consideran como preliminares.

RESUMEN

En este artículo se presenta un intento de estudiar la influencia de la polinización artificial en el cuajamiento de frutos de un clon autoincompatible (Pound-12) y de determinar posibles cambios en carácteres morfológicos de la mazorca, como tamaño, grosor de la cáscara, número de semillas, etc. como resultado de cruces con clones diferentes. Se encontró que polinizaciones controladas aumentaron el cuajamiento casi tres veces, siendo 17.8 y 50.3 el número promedio de mazorcas en el árbol para plantas testigos y con control de polinización respectivamente. Se hicieron cerca de 75 polinizaciones controladas por árbol en aproximadamente 15 días.

Las polinizaciones controladas aumentaron el tamaño y peso de las mazorcas como también el número de semillas por mazorca.

En el período 1958-59 se han hecho cerca de 3.600 polinizaciones controladas comprendiendo 16 cruces diferentes. Se encontró que el Clon Pound-12 es autoincompatible (5.6% de cuajamiento en 500 autofecundaciones). También fué incompatible con pólen del clon Pound (9.8%). Otros cruces dieron como resultado hasta 60-70% de cuajamiento.

SUMMARY

This paper is an attempt to study the influence of hand pollination on fruit setting of a self-incompatible cacao clone (Pound-12) nd to determine possible changes in morphological characters of the acao pod, such as size, weight, thickness of shell, number of seeds, tc., as a result of crosses with different clones. It was found that and pollination increased fruit setting about three times, the average number of hanging pods per plant being 17.8 and 50.3 for control nd hand pollinated plants, respectively. About 75 hand pollinations ere performed per plant during approximately 15 days.

Hand-pollinations increased pod size and weight, as well as the umber of seeds per pod.

About 3,600 hand pollinations in 16 different crosses have been erformed in 1958-59. Clone Pound-12 was found to be self-incompatible 5.6% setting in 500 selfing). It also showed incompatibility with ollen of Pound-7, (9.8%). Other crosses resulted in about 60-70% etting.

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UNA NOTA SOBRE CONSERVACION DE SEMILLA DE CACAO

C. A. Hurtado*

Actualmente existe un problema evidente en lo que respecta tratamiento y embalaje de la semilla de cacao para transportarla a largas distancias, lo cual redunda en la mayoría de los casos en la pérdida de un elevado porcentaje de la germinación de dicl material.

El avance de las investigaciones en cuanto se refiere al me joramiento del material de propagación ha permitido obtener semi llas de magnificas características de productividad y que encien an grandes esperanzas para el futuro del cultivo de cacao, tales como las semillas clonales, ó mejor aun que éstas las semillas H bridas obtenidas por medio de la polinización controlada.

Por tales razones, la semilla de cacao ha elevado sus carac terísticas intrínsecas y por ello obtiene mayor valor comercial. los agricultores interesados por adquisición de este material me jorado, realizan fuertes inversiones para establecer sus planta ciones tratando de obtener el mayor número de plantas al moment de realizar sus almácigos.

Tales inversiones deben de ser respaldadas por medio de sis temas ó metodos de conservación de tal manera que no demanden co plicaciones en su uso, que esté al alcance de poder ser aplicado por cualquier productor de buena semilla, que sea práctico, econ mico y efectivo a la vez en cuanto se refiere a la conservación la viabilidad de la semilla.

Adquiere su máximo valor los estudios de conservación de se lla de cacao, por cuanto no siempre es factible de conseguir dic material con rapidez y en el momento oportuno, ya que el agricul tor necesita aprovechar las mejores condiciones de la semilla lo cual se puede obtener mediante acondicionamiento especial y simp

Algunos métodos usados para el mantenimiento de la viabilida de la semilla han permitido asegurar algunas veces una buena ger minación por espacio de 8 a 10 días, tales como los tratamientos con polvo de carbón, aserrín ó arena, pero a mayores días de los señalados no han respondido, perdiendo la semilla su viabilidad sea por deshidratación ó por rotura de la radicela en aquellas q inician la germinación durante el transporte.

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* Jefe, Departamento de Cacao, Estación Experimental Agrícola, Tingo María, Perú.

El tratamiento de mazorcas con una desinfección a base de pro-
etos fungicidas y luego un baño de parafina líquida, al parecer
sulta el más efectivo, sin embargo presenta inconvenientes en el
sto del transporte y volumen de carga que representa, sobre todo
se trata de un envío aéreo.

Alvim describe un método muy efectivo para la conservación de
viabilidad de la semilla y actualmente es muy usado, pero requie-
tiempo y mano de obra para ejecutar el pelado del tegumento, es-
cialmente cuando se trata de cantidades mayores de 10 kgs. de se-
lla fresca.

En base de algunas recomendaciones que dá Alvim respeto al tra-
miento de las semillas, se procedió a realizar algunos ensayos
ndientes a modificar éste, especialmente en lo referente al pela-
del tegumento.

Se procedió primero a dosificar las cantidades de cal viva (cal
mercial) con el objeto de observar si producian daños en la se-
lla traducidos por una evaluación del poder germinativo. Se sabía
emás los efectos de la cal sobre el mucílago de la semilla al que
nde a eliminarlo, haciéndolo facilmente desprendible del tegumen-
.

Se usaron cantidades de 20, 30, 40 y 50 gramos de cal por cada
senta semillas, aplicadas directamente sobre el mucílago e impreg-
ndolas bien mediante un removido. Se hicieron observaciones del
der germinativo a los 10, 20 y 30 días, comparándolas con un gru-
que sirvió como testigo que para el presente caso fue tratado con
rrín.No se aplicó ningún fungicida, pués solo se pensó en obser-
el efecto de la cal en la germinación de la semilla.

Se tomaron 60 semillas por tratamiento con un total de 300, sem-
das en cajones con aserrín; cada 10 días se sembraban en número
20 extraídas de bolsas de polietileno donde previamente se guar-
on.

Los resultados se anotan en el cuadro No. 1.

dro No 1 Efectos de la cal sobre el poder germinativo de la semilla de cacao

Tratamientos	Días de conservación en procentaje de germinación		
Aserrín	10	20	30
Testigo	95	30	0
20 grs de cal	100	20	0
30 " " "	95	35	0
40 " " "	100	25	0
50 " " "	90	30	0

Se observó que las semillas presentaron mucho moho, por la falta de protección con fungicida. Hubo germinación de las semillas en las bolsas en todo los tratamientos, lo que se produjo a partir del sétimo día.

Aparentemente no hubo daños de la cal sobre la semilla lo que se comprueba por el porcentaje obtenido a los 10 días de sembradas.

El mucílago se desprendió fácilmente con mayor proporción de cal frotando la semilla sobre una superficie blanda pero ligeramente áspera, tal como un saco de yute que se usó para eliminar la pulpa.

Este ensayo sirvió de base para suprimir el pelado del tegumento de la semilla y reemplazarlo por un despulpado mediante la aplicación de la cal.

Para eliminar el moho formado sobre las semillas se aplicó Phygon XL en suspención al 1%, tal como recomienda Alvim en su método. Luego se secó ligeramente las semillas con el objeto de disminuir el contenido de humedad de éstas, para conservarlas mejor evitar la germinación durante el almacenaje.

Según esto, se realizó un ensayo para determinar el óptimo de pérdida de humedad de la almendra para conservarse en buen estado como semilla.

El proceso es el siguiente: Se tomaron 540 semillas de una mezcla de los clones Pound; se aplicó a dichas semillas 450 grs. de cal según los resultados obtenidos en cuadro No.1, a razón de 50 grs. de cal por cada 60 semillas, lo que equivale a 1/3 del peso total de las semillas aproximadamente, teniendo en cuenta que cada semilla pesa 3 grs. en promedio.

Las semillas asi tratadas se frotaron sobre una superficie ligeramente áspera tal como el saco de yute. Una vez separado el mucílago, se les dió un lavado rápido en una suspención de Phygon al 1%. Luego se separaron en grupos de 140 semillas y se guardaron en bolsas de polietileno al término de los siguientes tratamientos:

A. Embolsado inmediato
B. Embolsado después de una hora de secado
C. Embolsado despues de dos horas de secado
D. Embolsado despues de cuatro horas de secado

El secado se hizo a la sombra sobre una mesa y para determinar pérdida aparente de peso de las semillas, se hicieron registros peso antes y después de los tratamientos. Se obtuvo 42.7% de disnución de peso después del desprendimiento del mucílago (despulpa-). Las semillas libres del mucílago y luego secadas a la sombra, rdieron aparentemente el porcentaje expresado en el Cuadro No.2.

adro No.2 Pérdida aparente de peso de las semillas expresado en porcentaje despues del secado

Tratamientos	%
A	-
B	3.74
C	5.26
D	12.11

Después de haber sido embolsadas durante 10, 15, 25, 30, 35, y días, las semillas fueron sembradas en cajas de aserrín en grupos 20, a fin de determinar el efecto de los tratamientos en la germición. Se muestra los resultados en el cuadro No.3.

adro No.3 Efecto de los tratamientos sobre la germinación de la semilla de cacao

Tratamientos	Dias de conservación y porcentaje de germinación						
	10	15	20	25	30	35	40
A	100	95	90	85	80	50	25
B	100	95	100	100	90	55	35
C	100	80	100	90	75	50	10
D	95	25	75	35	25	0	0

Los tratamientos B y C mostraron ser los más efectivos, es decir aquellos en los cuales se rebajo el contenido de humedad de la semilla, en un limite de 3% a 5%. La germinación fue muy buena hasta despues de 30 días.

El tratamiento A, presentó semillas germinadas dentro de la bolsas a partir de los 15 días. El tratamiento D, fue muy variab en la germinación y las plantitas desarrollaron en forma deficie te.

RECOMENDACIONES

Según los resultados obtenidos, que no difieren mucho del r todo de Alvim, se recomienda el siguiente sistema de conservaci el que viene usándose en el Perú con buenos resultados:

1. Mezclar la semilla con cal removiéndola y luego frotarl sobre un saco de yute.
2. Separar la semilla de los restos de mucílago.
3. Lavar rápidamente las semillas en una suspención de Phygon al 1%.
4. Secar a la sombra las semillas por espacio de una a do horas.
5. Guardarlas en bolsas de polietileno con capacidad de 1 2 Kgs.

RECOMMENDATIONS

According to the results obtained, the following procedure which is being used in Peru with good results, is recommended:

1. Mix the seeds with lime, then place them on jute sack- ing.
2. Separate the seed from the mucilage.
3. Wash the seeds rapidly in 1% Phygon.
4. Dry the seeds in the shade for two hours.
5. Store the seeds in polyethylene bags containing 1 to 2 Kg. each.

A PRELIMINARY EXPERIMENT ON THE PROTECTION OF CACAO SEEDS

A.J. Hansen[M] & J.R. Hunter[MM]

INTRODUCTION

Today, cacao is being shipped in quantities within and be-
een countries. Since the seed loses its viability under normal
nditions in 10-15 days, shipping has to be done by air, a ra-
er expensive process. Several workers have investigated, in the
st, the possibilities of protecting the seed during shipment.
ans (1950) described the problems involved in seed protection
d at the same time recommended shipment in charcoal. In prac-
cal experience, his results could not always be confirmed and
reover airlines complained about mucilage and charcoal dust
eping out of containers. Alvim (In Press) reported at the VII
cao Conference about good shipping results after removal of
e testa. Naundorf (1955-1959) published a report on seed treat-
nt with 3 fungicides without giving technical details. Hunter
959) has expressed the opinion that the quick decline of cacao
ed viability is due to fungal attack.

It seemed that a method using a combination of seed testa
moval and fungicidal treatment, could be of value in preserv-
g the viability of cacao seed.

MATERIALS AND METHODS

The mucilage and seed testa was removed from seeds of mat-
e pods with the help of sawdust. Groups of 400 seeds were then
eated with 10 different fungicides.

The quantities used in each case were the ones recommended
the manufacturers. Seeds from wet treatments were dried after
e application. The seeds were then stored at room temperature
30C) in tightly sealed plastic bags. After 3, 10, 30 and 60
ys, lots of 100 seeds from each treatment were sown in unste-
lized sawdust. They were placed under a shade roof and kept
ist. Weekly data of germination percentage and a final size
asurement 8 weeks after sowing were taken. The fungus flora of
e stored seeds was investigated twice.

[M] Pathologist, Inter-American Cacao Center

[MM] Physiologist, Coffee, Cacao & Rubber Technical Services Unit, Inter-American Institute of Agricultural Sciences, Turrialba, Costa Rica.

RESULTS

Due to the small size of the experiment and the great variation between the three repetitions (Table 1) no statistical analysis was attempted. Nevertheless the results seem of considerable interest:

1. Ten days after sowing, the germination percentage was fairly even at 90% in the treatments and in the check.
2. In all cases, the germination percentage after 30 days was higher in the first repetition than in the second or third.
3. All treatments with the exception of Captan had a considerable protective effect on seeds stored for thirty days. Arasan, Ceresan and Fermate contributed to a fairly high survival percentage in at least 2 repetitions.
4. After 60 days of storage, only the seeds treated with Ceresan, Lonacol and Arasan had at least 20% germination in at least 1 repetition.
5. Granosan M at the concentration used, had apparently an excellent protective action, but at the same time inhibited germination. Arasan and especially Ceresan caused a slight delay in germination, stunting, and a light chlorosis of the leaves.
6. Seeds treated with Lonacol consistently grew into taller plants than the check.
7. In all groups some fungus mycelium developed on the beans. Development was slowest and least on the seeds treated with Arasan, Granosan and Ceresan. Molds, Colletotrichum and Fusarium were encountered in all groups, and Nectria on several beans.

DISCUSSION

The reason for the great variation between repetitions is not clear. It may be connected with the fact that the beans of the first repetition had been dried for some hours before the treatment while those of the other repetitions were treated after a shorter drying time. Even so, it seems safe to conclude that all treatments with the exception of Captan were effective

a higher or lesser degree. This confirms the opinion that the ss of viability is due in part to fungus attack and not only physiological aging processes. The greater heights attained some treated groups is considerable; however, it seems too rly to speculate on possible reasons for this. The method of anting in unsterilized sawdust has the advantage of conveni- ce. Since a rather high percentage of plants dies after hav- g fully germinated, sterilized sawdust will be used in the fu- re. The phytotoxic effect of some of the materials points to e need for careful investigations about the maximal permissi- e doses of each fungicide.

ble 1 Germination percentages of cacao seeds with and without treatment

	Number of germinating seeds out of 100 planted								
	After 10 days			30 days			60 days		
petitions	1	2	3	1	2	3	1	2	3
emesan Jr.	100	78	98	96	0	0	0	0	0
emesan Bel	98	77	82	47	2	0	9	0	0
rasan	91	92	96	90*	62	0	0	8*	0
ptan	100	59	89	0	0	0	0	0	0
eresan	97	98	98	98	81	20	53	26*	16*
rmate	100	90	99	92	28	0	0	0	0
nacol	100	63	95	93	0	0	21	0	0
ygon	99	95	93	48	26	0	0	0	0
ergon	96	96	93	92	0	0	23	0	0
eck	89	77	84	0	0	0	0	0	0

* Some (in the case of Arasan all) of these germinated but did not develop into plants due to apparent phytotoxic effect.

SUMMARY

Ten fungicides were tested as to their protective action on mature cacao seeds. All of them, with the exception of one, prolonged the viability of the seed considerably. In some cases, phytotoxic effects were observed. Lines for further investiga- tions are indicated.

RESUMEN

Se ensayaron diez fungicidas distintos para determinar su actividad protectora sobre la semilla madura del cacao. Todos, con la excepción de uno, prolongaron la viabilidad de la semill de manera considerable. En algunos casos se observaron efectos fitotóxicos. Se señalan pautas para una futura investigación.

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SUMMARY OF DISCUSSION

. G. Havord (IAIAS)

This work has been going on for some ten years and we have
en obtaining the same results. From Turrialba we have sent out
eds in varying quantities, some of them being very large ship-
nts. Until recently we have used a modification of Alvim's
thod in which the testa is removed with the aid of sawdust and
e bean is treated with phygon. We have obtained variable re-
lts with this method, some shipments giving as high as 90% ger-
nation after a delay of two weeks whilst other shipments with
e same treatment and same period failed to germinate. I think
at it is important that this work continue so that we can locate
e cause of variability.

. J.V. Soria (IAIAS)

In these experiments we should also consider a factor that
s suggested a few years ago, namely, the age of the pod. If
e pod is too old the seed has already germinated. On the other
nd temperature can have an effect on conservation of the viabi-
ty of the seeds. In one of our experiments we found that cacao
eds immersed for one minute in water at 4°C. failed to germinate.

. J. Leon (IAIAS)

With reference to peeling of the testa by hand, we have found
at in Costa Rica three workers on a contract basis can peel
,000 seeds a day. I feel that this is an economical rate even
r commercial purposes.

RESULTADOS PRELIMINARES SOBRE EL EFECTO DE TRES SISTEMAS DE PODA EN CACAO CLONAL*

Julio Cabrera Ortiz** y E. T. Bullard***

INTRODUCCION

En el Ecuador, en la generalidad de las plantaciones de caca no se practica ninguna clase de poda; persistiendo en el agricult la idea de que mejores rendimientos se obtienen en árboles a libr crecimiento.

En numerosos trabajos se ha indicado la finalidad de la poda diversos sistemas a seguirse y las épocas apropiadas para efectua la. Sin embargo se conoce poco en cuanto a su efecto sobre el re dimiento y, aún más, no se ha evaluado su eficiencia en lo que a control de enfermedades fungosas se refiere; siendo éstos los in diatos objetivos del presente trabajo.

MATERIALES Y METODOS

En 1953, a plena exposición solar, se inició un ensayo de co paración de podas en cacao clonal. En un diseño experimental de parcelas subdivididas, con cuatro repeticiones y nueve plantas po parcela distanciadas 4 m. x 4 m., se distribuyeron los tratamient principales que constituyen los sistemas de poda. Los tratamient secundarios corresponden a los siguientes clones: EET-48 (Santa sa 34, variedad Nacional), EET-162 (Curiquingue 2, Nacional x Ven zuela Amarillo) y EET-212 (El Vergel 203, Nacional x Venezuela Mo do).

Los sistemas de poda comparados son:

A. PODA FUERTE: se eliminan chupones, ramas bajeras y secunda- rias desde la base hasta los dos tercios de la altura total de la planta.

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* Una contribución de la Estación Experimental Tropical de Pichi lingue sostenida por el Servicio Cooperativo Interamericano de Agricultura mediante un convenio especial entre los EE.UU. y Ecuador

** Asistente del Depto. de Horticultura de la Estacion Experimenta Tropical de Pichilingue

*** Consejero de Investigaciones en Horticultura, USOM/Ecuador

PODA LIGERA: se eliminan chupones, ramas bajeras y secundarias desde la base hasta un tercio de la altura total de la planta.

ARBOLES DE FUSTE RECTO: se seleccionó un chupón y se permitió su crecimiento mediante poda paulatina de la planta que le dió origen.

LIBRE CRECIMIENTO: testigo sin poda.

Se iniciaron las podas en junio de 1956 y se han realizado dos ees por año. Una se realizó en Junio coincidiendo con la termina on de la estación lluviosa y otra en noviembre, antes que se ini- el invierno. Hasta la fecha, en algunas plantas, no se ha esta cido el sistema de fuste recto por falta de brotación de chupo- .

Siendo el principal objetivo, determinar el efecto de la poda re el rendimiento e incidencia de Escoba de Bruja y Monilia; se istran datos de producción, infección de Escobas e infección de ilia. Para tener una mejor información, desde el año 1959, los os de infección de Escoba de Bruja se han dividido en: Escobas etativas, Escobas de Cojinetes y de la mazorca (Chirimoyas). A- ás, se lleva el dato sobre número de mazorcas cherelles (Cherelle t).

Los análisis de la variancia se hicieron con los datos corres- dientes a cada año y un análisis final con los datos acumulados cuatro años.

RESULTADOS

En el cuadro Nº 1 se muestran los datos obtenidos de 1956 a 9 inclusive, sobre rendimientos de cacao seco expresados en quin- es por hectárea.

Cuadro Nº 1 Comparación de podas en tres clones de cacao

Resúmen de rendimientos de cacao seco expresados en quintales por hectárea

PODAS	1956	1957	1958	1959	Promedi 1956-19
Poda Fuerte	2.92	13.53	7.68	9.49	8.40
Poda Ligera	3.68	11.96	11.80	16.55	11.00
Arboles de Fuste Recto	1.43	7.13	7.58	12.45	7.15
Libre Crecimiento	2.52	9.79	10.29	21.92	11.14
Promedio	2.63	10.60	9.34	15.10	9.42
D.L.S. 5%	N.S.	N.S.	N.S.	6.54	3.39
D.L.S. 1%	-	-	-	9.39	N.S.
CLONES					
EET- 48	1.51	5.23	7.03	13.96	6.3
EET-162	4.86	19.90	14.27	18.80	14.4
EET-212	1.54	6.68	6.71	12.55	6.8
D.L.S. 5%	1.38	5.05	4.42	4.87	2.66
D.L.S. 1%	1.87	6.85	5.99	6.60	3.61
% Coef. de Variación	73	66	65	44	3

De los datos y resultados anteriores se desprende que hay a na variación en cuanto al comportamiento de los diferentes siste de poda. Así, en el año 1956 es el tratamiento poda ligera el q presenta mejores rendimientos; en 1957 poda fuerte es el mejor d los sistemas comparados. En 1958 nuevamente es poda ligera y en es el testigo (sin poda) los que registran mejores rendimientos. el análisis correspondiente a datos acumulados de cuatro años, l sistemas poda ligera y libre crecimiento fueron significativamen diferentes a los tratamientos poda fuerte y fuste recto. La pro

ión de cacao seco del clon EET-162 es el significativamente superio
la de los clones EET-48 y EET-212.

En el cuadro NQ 2 se presentan los datos de infección de "Escoba
e Bruja", los mismos que se expresan en promedio por árbol y por año
e escobas vegetativas y de cojinete.

uadro No.2 Comparación de podas en tres clones de cacao
Resumen de infección vegetativa y de cojinete de "Escoba de Bruja"expresada en número promedio de escobas por árbol.

ODAS	1956	1957	1958	1959	Promedio 1956-1959
oda Fuerte	12.08	18.42	259.19	105.31	98.75
oda Ligera	13.53	13.72	314.66	148.67	122.64
rboles de Fuste Recto	8.81	11.47	286.63	119.42	106.58
ibre Crecimiento	9.89	9.94	271.50	89.22	95.14
romedio	11.08	13.39	282.99	115.65	105.78
LONES					
ET- 48	14.46	16.38	349.27	111.54	122.91
ET-162	11.88	11.93	251.99	91.73	91.88
ET-212	6.90	11.85	247.73	143.69	102.54
.L.S. 5%	4.13	3.90	49.89	28.67	12.20
L.S. 1%	5.60	--	67.60	38.85	16.53
Coef. de Variación	51	40	24	3	3

No se encontró diferencia significativa en infección entre los
versos sistemas de poda, aún cuando el número de Escobas fué ma-
r en poda ligera. El Clon 162 presento un número inferior de Es-
bas en relación al clon 48, siendo su diferencia sifnificativa al
vel del 1%.

En el cuadro NQ 3 se presentan los datos de infección de Moni-
a, expresados en valores angulares y sus porcentajes correspondien
s.

Cuadro No. 3 Comparación de podas en tres clones de cacao

Resúmen de infección de Monilia expresada en valores angulares y porcentajes correspondientes.
Promedio por árbol

PODAS	1956		1957		1958		1959		Promedio	
	Ang.	%	Ang.	%	Ang.	%	Ang.	%	1956 Ang.	1959 %
Poda fuerte	5.05	0.78	20.00	11.70	44.64	49.40	38.62	39.00	27.08	20.70
Poda ligera	10.27	3.20	19.27	10.90	45.99	51.70	40.80	42.70	29.08	23.60
Fuste recto	7.03	1.50	12.32	4.60	48.21	55.60	41.21	43.40	27.19	20.90
Libre crec.	7.67	1.80	19.73	11.40	49.64	58.10	36.07	34.70	28.26	22.40
Promedio	7.50	1.82	17.83	9.65	47.12	53.70	39.18	39.95	27.90	21.90
CLONES										
EET- 48	8.35	2.10	13.97	5.80	45.49	50.80	35.26	33.20	25.74	18.90
EET-162	6.17	1.20	22.21	14.30	45.60	51.10	45.73	51.30	29.96	24.90
EET-212	7.99	2.00	17.29	8.80	50.28	59.20	36.54	35.50	28.02	22.10
D.L.S. 5%	N.S.		4.70		N.S.		4.97		3.12	
D.L.S. 1%	-		6.38		-		6.74		4.22	

Aún cuando el porcentaje de infección de Monilia en poda ligera
é mayor, no se encontró diferencia significativa entre los diversos
stemas comparados. En clones, fué el EET-162 el que presentó mayor
rcentaje de infección, y su diferencia es significativa al nivel
l 1% en relación con el clon EET-48.

De los resultados presentados, se desprende que la poda fuerte
ecta considerablemente el rendimiento de cacao y que los diversos
stemas de poda no tienen ningún efecto en el control de la infec-
ón tanto de Monilia como de Escoba de Bruja.

Es necesario indicar que el presente estudio está planeado para
ince años de duración, y los datos reportados corresponden solamen-
a cuatro años, por lo mismo, los resultados obtenidos deben consi-
rarse como preliminares.

RESUMEN

En 1953 se comenzó un experimento de podas con tres clones de
cao en la Estación Experimental Tropical de Pichilingue, Ecuador.
s resultados preliminares de rendimiento de los cuatro primeros
os indican que los árboles que recibieron poda liviana y los no
dados rindieron más que los árboles con poda fuerte o que los que
enen un chupon. Las podas no afectaron significativamente en la
cidencia de Escoba de Bruja o de Monilia.

El clon EET-162 rindió significativamente más que los clones
T-48 o EET-212. El clon EET-162 fué atacado por Escoba de Bruja
gnificativamente menos que el clon EET-48. El clon EET-162 tiene
rcentaje más alto de Monilia que el clon EET-48.

SUMMARY

A pruning experiment was started in 1953 at the Tropical Experi-
nt Station at Pichilingue, Ecuador, on three cacao clones. The
eliminary yield data of the first four years indicate that the
ees receiving light pruning and no pruning yielded more than the
avily pruned trees or the trees pruned to a chupon.The pruning
eatments had no significant effect on the incidence of Witches
om or Monilia.

Clone EET-162 yielded significantly more than clone EET-48 or
-212. Clone EET-162 had significantly less Witches Broom than
ne EET-48. Clone EET-162 has a higher percentage of Monilia pods
n clone EET-48.

PROPAGACION DE CACAO: COMPARACION ENTRE RAMILLAS E INJERTOS CON RELACION A TRES DISTANCIAS DE SIEMBRA *

Jorge Gutiérrez G.** y Ervin T. Bullard ***

INTRODUCCION

La propagación del cacao por la vía asexual promete ser el medio más seguro de obtener buenas plantaciones, toda vez que el trabajo fuere iniciado con clones seleccionados en base de buena producción y resistencia a enfermedades. Por supuesto que un árbol de cacao obtenido vegetativamente, conserva fielmente las características del que lo originó mientras las condiciones ambientales y los cuidados culturales a que sea sometido, se identifiquen con las originales (1).

Los métodos de mayor uso en la propagación vegetativa son el enraizamiento de ramillas y el injerto.

Es aún asunto de discusión si las plantas producidas por estaca alcanzan mayor o menor producción que las injertadas (4). El Centro Interamericano del Cacao (3) informa que las estacas de todos los clones UF de un experimento conducido en Turrialba, rindieron más que los injertos y plantas de semilla de los mismos clones en el primer año de cosecha.

También se discute aún sobre la conveniencia o inconveniencia de un mayor o menor aprovechamiento superficial del suelo (2).

El estudio de estos problemas constituye el principal objetivo de este experimento, relacionando al mismo tiempo estas condiciones con la incidencia de las enfermedades Monilia y Escoba de Bruja.

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* Contribución de la Estación Experimental Tropical de Pichilingue sostenida por el Servicio Cooperativo Interamericano de Agricultura mediante un convenio especial entre los EE.UU. y el Ecuador.

** Horticultor, Estacion Experimental Tropical de Pichilingue

*** Consejero de Investigaciones en Horticultura, USOM/Ecuador

MATERIALES Y METODOS

Este trabajo fue iniciado en 1951 en Pichilingue; la plantaión formada con 90 árboles del clon EET-19 no posee sombra y se an acumulado desde 1955 hasta este momento datos de producción e almendras de cacao, e incidencia de Escoba de Bruja y Monilia oreri. Con estos datos se han realizado anualmente los corresondientes análisis de la variancia.

El diseño experimental utilizado fue el de parcelas subdividias con dos tratamientos principales que corresponden a los injeros y a las ramillas y tres sub-tratamientos que se refieren a las istancias que se comparan y que son 2 x 5, 3 x 5 y 4 x 5 metros. l número de repeticiones es de tres, y cada sub-parcela tiene 5 rboles.

Los injertos se realizaron por el sistema de cuña sobre planitas de semilla de 6 meses de edad.

RESULTADOS Y CONCLUSIONES

Los datos de producción de almendras, desde 1955 hasta 1959 se resentan en el cuadro No. 1, expresados en quintales de cacao seco or hectárea.

uadro No. 1 - Producción promedia de cacao seco en quintales por hectárea, de 5 anos (1955-1959).

	Sistema Propagación		Distancias			C.V.
	Ramillas	Injertos	2 x 5	3 x 5	4 x 5	%
1955	17.90	14.87	22.37 x	15.67	11.12	28
1956	14.34	21.94	29.44 x	14.90	10.09	48
1957	11.84	9.43	15.07	8.89	7.95	55
1958	22.55	24.62	33.57 x	21.88	15.32	36
1959	18.95	26.47	27.34	18.77	22.03	42
955-1959	17.12	19.47	25.55 xx	16.02	13.30	23

x Significativo al nivel del 5%
x Significativo al nivel del 1%

De lo expuesto en el cuadro se desprende que no hay diferencia significativa entre la producción de cacao seco producido por árboles propagados por ramilla y por injerto.

En cuanto a las distancias que se comparan, se observa una mayor producción al espaciar los árboles a 2 x 5 m., esto se explica por el mayor número de árboles por superficie. Este aumento de producción alcanza diferencia significativa al nivel del 5% en los años 1955, 1956 y 1958. Al analizar los promedios para los 5 años se encuentra diferencia altamente significativa al nivel del 1% para esta misma distancia. Entre 3 x 5 y 4 x 5, es mayor la producción para la primera distancia, sin llegar a ser significativa.

Se observa interacción estadísticamente significativa al nivel del 5% entre sistemas de propagación y distancias en los años 1956 y 1958, lo cual puede apreciarse en los cuadros Nos. 2 y 3, respectivamente.

Cuadro No. 2 - Producción de cacao seco en qq/Ha. 1956

Distancias	Sistemas		Promedios
	Ramillas	Injertos	
2 x 5	15.70	43.17	29.44
3 x 5	16.33	13.47	14.90
4 x 5	11.00	9.17	10.07
Promedio	14.34	21.94	18.14
D.L.S. 5%			11.49
1%			N.S.
N.S.			
Interacción 5%			16.25

Cuadro No. 3 - Producción de cacao seco en qq/Ha. 1958

2 x 5	23.20	43.93	33.57
3 x 5	26.73	17.03	21.88
4 x 5	17.73	12.90	15.32
Promedio	22.55	24.62	23.59
D.L.S. 5%			11.45
1%			N.S.
N.S.			
Interacción 5%			16.20

En el cuadro No. 4 se expresan los porcentajes promedios de azorca con Monilia causados por Monilia Roreri Cif. y Par. De los romedios se desprende que no hay diferencia estadísticamente sig-ificativa entre los sistemas de propagación por ramilla y por in-ertos, ni entre las distancias que se comparan.

adro No. 4 - Porcentaje de mazorcas con Monilia. Promedios de 5 años (1955-1959).

	Sistema de Propagación		Distancias			C.V.
	Ramillas	Injertos	2 x 5	3 x 5	4 x 5	%
955	7.22	5.33	7.34	5.34	6.17	85
956	6.56	5.00	8.17	4.50	4.67	114
957	22.11	13.44	17.00	18.83	17.50	53
958	29.00	43.00	28.33	36.67	43.00	32
959	2.44	2.00	1.33	2.34	3.00	59
955-1959	13.47	13.75	12.43	13.54	14.87	33

Debe indicarse que se realizó control químico de la Monilia con uso de Zineb únicamente en el año 1959, lo cual se refleja en los jos promedios de incidencia observados en tal año.

En el cuadro No. 5 se expresa los promedios de Escobas (Marasmus perniciosus) tanto vegetativas como en cojinete registrados en s 5 años de observación. Solamente en el año 1956 se encuentra mayor incidencia de Escobas, significativa el nivel del 5% en los árboles de ramilla. En los años siguientes no hay diferencia significativa; igual observación se puede hacer en las distancias comparadas.

Cuadro No. 5 - Incidencia de Escobas. Promedios de 5 años (1955-1959).

	Sistema de Propagación		Distancias			C.V.
	Ramillas	Injertos	2 x 5	3 x 5	4 x 5	%
1955	292.44	300.67	266.16	321.50	302.00	27
1956	80.56 x	67.78	63.83	78.00	80.67	28
1957	51.78	49.56	40.50	51.50	60.00	28
1958	316.89	283.89	274.67	258.66	367.83	44
1959	213.67	245.00	182.33	205.34	300.34	35
1955-59	191.07	189.38	165.50	183.00	222.17	30

x Significativo al nivel del 5%

RESUMEN

Se comparan experimentalmente dos sistemas de propagación de cacao, por ramillas enraizadas y por injertos, en relación con tr distancias de siembra: 2 x 5, 3 x 5 y 4 x 5 metros.

Los resultados obtenidos en 5 años de observaciones nos indi can que se alcanza una mayor producción sembrando a 2 x 5 metros. Entre la producción de las ramillas y los injertos no se aprecia diferencia significativa.

En cuanto a incidencia de las enfermedades Monilia y Escoba de Bruja no se hallan diferencias estadisticamente significativas entre los dos sistemas de propagación ni entre las tres distancias consideradas en el experimento, excepto para el año 1956 en incid cia de Escoba en ramillas.

SUMMARY

An experiment was started in 1951 at the Tropical Experiment ation in Pichilingue, Ecuador, to compare the effect of propa- ting cacao by cuttings and cleft grafts on young stock. A split ot design was used with propagation methods at main plots and anting distances as subplots.

There was no significant difference in yield or per cent of onilia pods between the two propagation systems used. In 1956 e plants propagated by cuttings had more Witches'Broom than ose propagated by cleft grafts.

The plants spaced 2 x 5 meters produced more cacao beans in 55, 1956 and 1958 than the plants spaced at wider spacings but ere was no effect of plant spacing on per cent of Monilia pods Witches'Broom.

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PROPAGADOR TIPO GUATEMALA

Leonel Anleu[*]

INTRODUCCION

El deseo de muchos agricultores de dedicarse más intensivam
cultivo del cacao en Guatemala, hizo necesaria la ampliación de
trabajos de la Sección de Cacao del Instituto Agropecuario Nacio
el cual ante ese interés aumentó la multiplicación de plantas po
sistemas vegetativos, (injertos y estacas enraizadas) siguiendo
nicas más avanzadas.

OBJETIVOS

En 1956 al iniciarse la propagación por estacas se tuvo en
mente el aprovechar materiales de fácil obtención y de bajo cost
en Guatemala para la hechura de propagadores, que aparte de ser
fácil fabricación tuvieron además condiciones ideales para logra
un alto porcentaje de enraizamiento; aprovechando al mismo tiem
la producción de productos plásticos lanzados al mercado por una
industria de reciente fundación en el país.

RAZONES

Cuando en 1956 se comenzó a trabajar en la propagación por
estacas, se utilizaban propagadores de otro tipo, pero con estos
se lograban bajos enraizamientos (55 a 60%) lo que venía a ocasi
nar pérdidas de materiales con el subsecuente alto costo de pro
ducción.

MATERIALES

Los materiales que se usaron fueron reglas de madera de 1"
x 2½" de diferentes largos y polietileno transparente de 0.03 m.
grueso. Con estos materiales se hicieron los propagadores o tien

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[*] Depto. Hule-Cacao. Instituto Agropecuario Nacional, Guatemala

.56 m. de ancho por 3.60 de largo, 60 cm. de alto en los lados
cm. de alto en la unión de las tapaderas. Estas tapaderas pa-
evitar quebraduras por lo largo y delgado de las reglas, se divi-
ron en dos. El propagador se encuentra sentado en un piso de are-
y tiene una capacidad de 264 bolsas.

La humedad dentro de los propagadores se proporciona por medio
eblineras con orificio de 0.28", en número de 4 en cada propa-
r y son accionadas por una bomba centrífuga, poniéndose a fun-
ar cada hora por espacio de 5 minutos. La temperatura en el in-
or del propagador oscila entre 22 y 31° C.

Los propagadores se encuentran bajo techo mixto, 50% de lámina
Zinc y 50% de lámina plástica blanca la cual deja pasar de 80 a
de luz; es decir que los propagadores reciben entre un 45 a un
5% de luz.

Las estacas se preparan dejando de 5 a 6 hojas a cada una y son
stas a enraizar en bolsas de polyetileno de color negro de 9" x 9"
un valor aproximado de $US 0.007 cada una. Como estimulante pa-
el desarrollo de raices se usa ácido Indolbutírico de 7 a 8,000
mezclado con Phygon (1).

Las estacas se comiezan a aclimatar a los 30 dias y se lleva a
en la misma forma como lo hace el Instituto Interamericano de
ncias Agrícolas (3). Tambien se acostumbra hacer pruebas con lí-
los de baja tensión para estar seguros de la debida aclimatación
las estacas, tal como lo recomienda Alvim (2).

Los clones que se están propagando son mezclas de UFCo., clo-
Mexicanos y Guatemaltecos.

RESULTADOS

A los 40 dias que es cuando las estacas son sacadas a los pre-
de endurecimiento se hace el recuento de estacas enraizadas,
ando un porcentaje de enraizamiento entre el 85 y 90%; el esta-
parente de las plantas es excelente, con un número de hojas muer-
por planta que varía de 1 a 3; estos datos son promedios obte-
s durante un año de propagación.

DISCUSION

1. Se estima que los resultados obtenidos se puedan mejorar ya sea aumentando o disminuyendo el número de riegos.

2. El número de neblineras en cada propagador puede variar de acuerdo a la presión que suministre la bomba.

3. No necesariamente tiene que contar con un techo como el que se usa en la estación, ya que lo importante es el grado de luz que pasa a los propagadores. Suponiendo que podría aprovecharse sombra de árboles, cobertizos con materiales vegetales o materiales plásticos.

4. Este tipo de propagador podría considerarse especialmente para centros de propagación temporales.

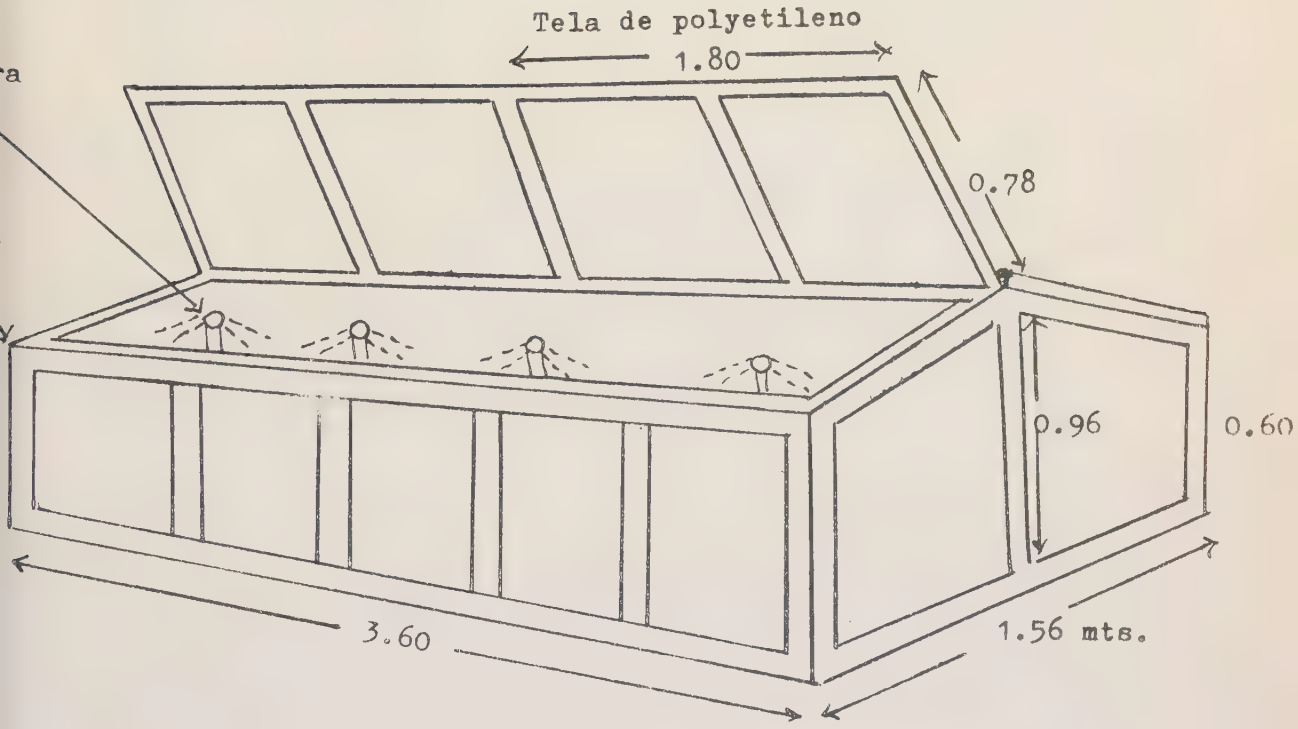
RESUMEN

Se informa sobre el enraizamiento del 85% al 90% obtenido en el propagador tipo "Guatemala", el cual está hecho de reglas de madera y polyetileno transparente de 0.003 m de grueso.

SUMMARY

The "Guatemala type" propagator made of wooden laths and transparent polyethylene is described. 85-90% rooting is obtai

PROPAGADOR GUATEMALA



(Measurements in metres)

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EL USO DE LA TELA MILIMETRADA EN ALMACIGOS DE CACAO

Leonel W. Anléu*

RESUMEN

Se informa sobre los buenos resultados obtenidos en almáci-
gos de cacao con el uso de la tela milimetrada plástica de color
verde.

Los ensayos y observaciones realizados en el Instituto Agro
pecuario Nacional indican que:

1. Con el uso de tela milimetrada se logra adelantar por l
menos de 4 a 6 meses en el aprovechamiento de patrones,
y éstos son más vigorosos que en almácigos puestos bajo
otros tipos de sombra.

2. En caso de lluvia esta tela elimina el impacto directo
las gotas de agua.

3. Aparentemente este material tiene un alto costo compara
con los otros, pero si se considera el tiempo que se ga
en que las plantas alcanzen su debido grosor y su dura-
ción (la que se calcula es de 3 a 5 años), puede decirs
que realmente es bastante económico.

Este tipo de tela es conveniente para que los agricultores
usen en almácigos de cacao, en vista de los magníficos resultados
obtenidos tanto en la Isla de Trinidad, como en Guatemala.

SUMMARY

The good results obtained in cacao seedling beds using green
plastic net are reported.

The experiments and observations by the Instituto Agropecuar
Nacional indicate that:

1. The use of the net seedling stocks are ready 4 to 6 mont
sooner, and these are more vigorous than when other type
of shade are used.

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* Departamento Hule y Cacao, Instituto Agropecuario Nacional, Guatemala

2. The net prevents the direct impact of raindrops on the plants.

3. The initial high cost of the net is more than offset by its long life.

This type of net is recommended for use in cacao seedling
ls, in view of the magnificent results obtained in Trinidad and
temala.

A COMPARISON OF FOUR TRANSPLANTING SYSTEMS WITH CACAO

J. Robert Hunter* & Edilberto Camacho V.**

INTRODUCTION

One of the chief problems of cacao management has been th tablishment of the crop in the field. Planting seed at stake no means always satisfactory and the transplanting of seedling budded plants and rooted cuttings from nurseries to the field results in considerable mortality which necessitates the addit expense of replanting.

The usual recommendation is to have the planting material individual containers (plastic bags, wicker baskets, bamboo pot etc.), which may be placed together with the plant, root, soil all directly in the field with very little damage or shock. Ot than this, the suggested practice is to transplant the young pl from the nursery to the field with a large ball of earth still rounding the roots and held there by sacking or banana leaves some similar material.

When neither of these methods is possible, owing to the st ture and texture of the nursery soil or owing to the great incr in transportation costs due to the extra weight of pots and soi transplanting is even more a serious problem.

Since there appears to be a definite increase in interest use of hybrid seedlings for planting material and since these a usually planted out in nursery beds, the present study is an at to review and compare recommended transplanting systems to asce which might be most economical and practical under present mana conditions.

REVIEW OF LITERATURE

One of the most thorough investigations into the matter (i ding a complete review of the literature of transplanting cacao to the date), was conducted by Schneck (7) in 1935 in which he pared six different methods of transplanting cacao seedlings.

* Plant Physiologist

** Asst. Horticulturist

Coffee, Cacao & Rubber Technical Services Unit, Inter-Americ titute of Agricultural Sciences, Turrialba, Costa Rica

erested principally in the most advantageous method which at the e showed the most rapid recovery of seedlings after setting in field. The six treatments were as follows:

A. Roots balled with earth and unpruned leaves

B. Roots balled with earth and one-half of the foliage cut off

C. Roots balled with earth and stem cut back to a height of 30 centimeters

D. Roots bare of earth and unpruned leaves

E. Roots bare of earth and one-half of the leaves cut off

F. Roots bare of earth and the stem cut back to a height of 30 centimeters

The conclusions reached as a result of his experiments were sum-ized as follows:

The least laborious, least expensive and also the most successful method of transplanting fifteen months old cacao seedlings is by cutting back the stem to a height of 30 centimeters and leaving their roots bare of earth.

In transplanting cacao seedlings from about fifteen to eighteen months old with either bare roots or balled with earth and unpruned leaves a low percentage of success may be expected.

When the seedlings were transplanted either with bare roots or balled with earth, pruning off one-half of the leaves did not prove as effective as cutting back the stem to a height of 30 centimeters.

Transplanting cacao seedlings fifteen months old should be done either with roots balled with earth or the roots carefully freed from soil and the stem cut back to a height of 30 centimeters so as to prevent excessive evaporation before the plant has become established in its new location.

In 1954, O'Rourke (6) carried out another study on transplanting tems based on results of work obtained by Hamner et. al. (5) and ner et. al. (3) using a plastic resin coating on the young plants. o seedlings were transplanted from the nursery to the field to shady and sunny locations under the following systems:

A. Untreated, bare-root seedlings (Check)

B. Seedlings dipped one time with VL-600 prior to transplanting

C. Seedlings dipped two times with VL-600 prior to transplanting

D. Seedlings covered with polyethylene bags prior to transplanting

Although O'Rourke stated that no definite conclusions could drawn, he indicated that the plants treated with the plastic resi survived to a much greater degree than the others, Actually, an analysis of the data indicates that the important factor in trans planting is whether or not the cacao seedlings are planted under shade. This, as has been indicated in other experiments (2) is o of the really critical factors in the establishment of cacao seed lings in the field.

In many areas of Central America, the recommended practice f transplanting cacao from the nursery as described by Gattoni and Ocaña (4) is to remove or cut off all of the leaves from the seed plants prior to the actual transplanting.

Work in progress by Camacho (1) at the Interamerican Institu for Agricultural Sciences particularly with regard to the marcott of cacao has indicated that polyethylene bags when properly appli may be of great benefit to promoting survival in transplanting se ling plants.

MATERIALS AND METHODS

Taking all of these facts into consideration, it was decided compare the best of all the systems indicated in the literature under a number of different transplanting conditions which might simulate natural situations. The different treatments included:

A. Plant stumped one week prior to transplanting at 30 centimeters. (Schuck) (Fig. 2)

B. Plants covered with plastic resin (O'Rourke)

C. Leaves removed from plants one week prior to transplanting. (Gattoni) (Fig.4)

D. Plants covered with polyethylene bags (Camacho) (Fig. 3)

E. Untreated plants transplanted bare-root (Check) (Fig. 1)

G. 1. Typical plants of *Theobroma cacao* after 10 months in the greenhouse on photoperiods of 8, 12, 14, and 16 hours, left to right.

In order to afford as much uniformity as possible to the trial, added material of the clone UF-667, eight months old was used.

On July 21, 1959, a total of 100 plants were stumped as recommended by Schneck (Treatment A) and a total of 100 plants had all of their leaves removed (Treatment B). These plants were left with all the others in the nursery beds for a period of one week. On July 28, 1959, all of the plants under treatment were dug up as carefully as possible so as not to damage the root system. Polyethylene bags (.003 gauge) measuring 60 x 30 cm. were placed over the stem and leafy part of 100 plants and the bag was then securely tied to the stem so as to inhibit water loss (Treatment C). To another 100 plants the plastic resin was sprayed according to the manufacturers recommendations (Treatment D).*

Half of the plants in each treatment were left unplanted in the open in the cool dense shade of the nursery without any other particular care or caution given to them, other than the fact that the polyethylene covered plants including the roots were completely enclosed within the bags. The other half were then taken to the field and planted in prepared holes in a randomized block design under two different shade conditions. All plants of this lot were planted within two hours after removal from the nursery. The two shade conditions, as measured by a photometer, were 50% shade and 75% shade.

Four days after removal from the nursery, the lot of seedlings which had been left in the open in the nursery shade was taken to the field and planted in the same design together with the previous lot.

Three weeks after the actual transplanting, the polyethylene bags were carefully removed from all plants to which they had been applied.

FIELD OBSERVATIONS

Except where direct sunlight penetrated the canopy for sufficient time to heat up the polyethylene enclosed plants, their definite resistance to the transplanting shock was immediately apparent.

During the first two or three weeks after transplanting, the check plants suffered the most, gradually losing their leaves and eventually dying.

It was obvious from all factors observed that control of transpiration is the critical factor involved.

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* "Wilt-Pruf" - Nursery Specialty Products Inc., Stebbing Road, Croton Falls, New York.

Although careful photometer readings were made in the two different planting locations on the date of transplanting, it was observed and confirmed by a photometer that the two shade conditions became more and more similar. The area where only 50% shade existed at the beginning of the experiment showed about 60% shade on September 17, 1959 and about 65% shade on October 28, 1959. This tended to eliminate any difference in growth and transplanting recovery which could be attributed to sun or shade conditions.

RESULTS

On September 17, 1959, 47 days after the transplanting, data were taken on the plants in the field. Although there was considerable difference in the growth and vigor of the plants they were classified only as "alive" or "dead". Results are given in Table No. I, below:

Table I. Condition of plants on September 17, 1959 (47 days after transplanting)

Treatments	Alive		Dead	
	Under 50% shade	Under 75% shade	Under 50% shade	Under 7 shade
Control (2 hours)	8	9	17	16
Control (4 days)	9	10	16	15
Polyethylene bags (2 hours)	24	25	1	0
Polyethylene bags (4 days)	25	25	0	0
Wiltproof sprayed (2 hours)	12	16	13	9
Wiltproof sprayed (4 days)	15	18	10	7
Defoliated (2 hours)	24	22	1	3
Defoliated (4 days)	23	23	2	2
Cutback (2 hours)	21	20	4	5
Cutback (4 days)	22	24	3	1

On October 28, 1959, 88 days after transplanting, further observations were made on these same plants. The results, given in Table II show very little difference from those given in Table I, with th

eption that two control plants which were indicated in Table I dead, were actually alive and that a number of the defoliated and back plants died between the two dates of observation.

ble II. Condition of plants on October 28, 1959 (88 days after transplanting)

reatments	Alive		Dead	
	Under 50% shade	Under 75% shade	Under 50% shade	Under 75% shade
ntrol (2 hours)	7	9	18	16
ntrol (4 days)	11+	10	14+	15
lyethylene bags (2 hours)	24	25	1	0
lyethylene bags (4 days)	25	25	0	0
ltproof sprayed (2 hours)	12	16	13	9
ltproof sprayed (4 days)	15	18	10	7
foliated (2 hours)	18++	18++	7++	7++
foliated (4 days)	17++	20++	8++	5++
tback (2 hours)	17++	16++	8++	9++
tback (4 days)	17++	18++	8++	7++

Two plants which were recorded as "dead" on September 17, 1959 (Table I) were actually alive and thus the descrepancy in the figures between the two Tables.

In the period between September 17, 1959 and October 28, 1959 a number of plants died as reflected in the changes in numbers between Tables I & II.

DISCUSSION

All treatments were far superior to the check or control in all es, even three months after transplanting. Enclosing the plants polyethylene bags brought plants through the shock of transplan- g with less mortality than the other three treatments which may be sidered as being equal with the exception that plants treated with tproof did better under the more intense shade conditions. Other n this particular treatment, the differences in shade appeared to e little effect.

There was also little or no effect as to whether they were planted immediately or were kept four days out of the ground in a cool damp shady place. This implies that if plants are to be tran ported for any distance they should be kept in such conditions if all possible.

The difference between these treatments comes down to one of economics. From a practical viewpoint, therefore, the success of transplanting cacao under these systems depends on which is the mo economical and easiest operation.

a) The plants covered with polyethylene bags were most succe ful in resisting the shock of transplanting, but the polyethy bags cost $0.03 each and although they may be reused several times this initial cost must be taken into consideration as w as the work involved in applying the bags and removing them from the plants.

b) Spraying the plants with the plastic resin also involves additional work and expense. The material used in this exper ment cost about US$1.00/100 plants and the extra time and equi ment used in its application must also be considered.

c) Defoliating nursery plants by cutting off all the leaves requires additional labor and care especially in the case of rooted cuttings or budded plants where there are usually a great many leaves on the plants.

d) Stumping or cutting back nursery plants from the standpoi of costs and labor is by far the most economical treatment which can be used as it requires but one quick operation per plant.

Taking all of these facts into consideration, however, it appe that under the conditions of the experiment that the most successfu means of transplanting cacao plants of nursery size is by covering aerial portions with polyethylene bags, planting them in at least 5 shade and leaving the bags over the plants for at least three weeks Using this method there is less chance for water loss through evapo tion or transpiration, less chance for insect or fungal attack, and more actual leaf surface for photosynthetic activity.

SUMMARY

Five different methods were tested for transplanting cacao nur sery material to two different shade conditions following two sepa- rate periods of exposure above ground. The treatments were (a) the

e of polyethylene bags to enclose the aerial portions of the plants;) the use of plastic resin as a spray to cover the aerial portions the plants, (c) defoliation one week prior to removal from the nur- ry, (d) stumping or cutting back to a height of 30 centimeters one ek before removal from the nursery and (e) check or control which plies no treatment.

Results from this trial are summarized briefly as follows:

1. The most efficient, although not the most economical, method of transplanting nursery plants is by the use of polyethylene bags. However, these plants when in the field must be in at least 50% shade all of the time for direct sunlight will heat up the interior of the bags within a very short time sufficiently to cause death.

2. The least expensive and easiest transplanting method is to cut back the nursery plant one week before transplanting.

3. It is felt that perhaps a greater success in transplanting may be achieved if a longer period is allowed between the time the plants are stumped or cut back and the time they are removed from the nursery. Trials are now in progress on this point and will be published elsewhere.

RESUMEN

Se utilizaron cinco métodos diferentes para transplantar lantas de viveros a dos condiciones diferentes de sombrío des- ués de dejar las plantas por dos períodos distintos de exposi- ión en las camas del vivero. Los tratamientos fueron (a) el so de bolsas de polietileno para encerrar las porciones aéreas e las plantas; (b) el uso de una aspersión de resina plástica ara cubrir las partes aéreas de las plantas, (c) defoliación na semana antes de sacar las plantas del vivero, (d) descabe- amiento a una altura de 30 centímetros una semana antes de qui- ar las plantas del vivero y (e) testigo sin ningún tratamiento.

Los resultados de este ensayo se resumen a continuación:

1. El método más eficaz, aún cuando no el más económico para transplantar las plantas de viveros, es por el uso de bolsas de polietileno. Sin embargo, cuando estas plantas están en el campo deben tener por lo menos un sombrío del 50% en todo momento, porque la luz solar directa en muy poco tiempo calienta el interior de los sacos hasta el punto de matar la planta.

2. El método menos costoso y más fácil es descabezar la planta en el vivero una semana antes de transplantarla.

3. Se considera que talvez se podría lograr mayor éxito en el transplante de las plantas si el período entre el descabezamiento de las plantas y el momento de sacarlas del vivero fuera mayor. Ya se están haciendo ensayos sobre el particular, y los resultados serán publicados más adelante en algún otro informe.

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SUMMARY OF DISCUSSION

A.F. Mackenzie (West Indies)

Should not the full cost of the entire process of establish-
it be taken into account in comparing your four transplanting
tems?

A.J. Hansen (IAIAS)

I fully agree but my experience is that the cost of labour
ies from territory to territory and also with varying environ-
ital conditions. My point is that the final cost of establish-
it in the field is high, also we are dealing with valuable
terial and a successful method of transplanting must take into
count the best utilisation of scarce material.

E. Quartey-Papafio (Ghana)

Experiments in transplanting methods in Ghana have shown
at using basketed or paper-potted seedlings is superior to using
re-root seedlings.

There is far less transplanting loss when seedlings are trans-
nted young - about 3 or 4 months old - than when they are many
ths old and, therefore, root-bound. Pruning tap roots or root-
nd seedlings assists but does not give the success achieved with
ng seedlings.

B. Topper (Jamaica)

Due to our short rainy season, during which we plant out cacao
erial, we find that it is necessary to utilise a plant grown in
ontainer, that is at least three months old, previous to trans-
nting in the field. I should like to ask Dr. Hansen with re-
d to the polythene method, how long does the polythene bag re-
n with the plant in the field.

A.J. Hansen (IAIAS)

The polythene bags were left on the plant for at least three
ks.

Mr. G. Havord (IAIAS)

The interesting point about the polythene method is that
are able to achieve a high survival rate in the field, even wh
there was a 4-day interval between the removal from the nurser
bed and planting out. The main point of this method is its va
in territories with poor internal communications, so that bare
root seedlings in polythene can be moved over relatively long
tances and still survive when planted out in the field. Bare-
seedlings could also be shipped by air.

PAPERS ON PATHOLOGY AND ENTOMOLOGY

COMPORTAMIENTO EN RESISTENCIA A LA ESCOBA DE BRUJA DE LOS CLONES SILECIA-1 Y 5 TRAIDOS DEL ORIENTE ECUATORIANO *

E. Ampuero ** y R. Desrosiers ***

INTRODUCCION

La Escoba de Bruja, causada por el hongo Marasmius perniciosus Stahel, es una enfermedad del cacao que anualmente causa considerables pérdidas en algunos países cacaoteros. La enfermedad se encuentra bien distribuída en las zonas cacaoteras de Sud América, Trinidad y Tobago. Aún no se ha denunciado la presencia de la Escoba de Bruja en Centro América ni en Africa. El organismo patógeno ataca los tejidos meristemáticos en crecimiento rápido, tales como los brotes vegetativos, cojinetes florales y mazorcas, causando una hipertrofia característica.

Por muchos años se han llevado a cabo investigaciones para controlar la enfermedad. Se ha estudiado la posibilidad de controlar la Escoba de Bruja por medio de aspersiones con fungicidas protectores el uso de productos químicos erradicantes (3). A pesar de haberse obtenido una reducción en la incidencia de la enfermedad, los resultados no han sido completamente satisfactorios. También se ha recomendado la remoción de Escobas, con el objeto de reducir las fuentes de inóculo.

La heterogeneidad genética del cacao, introdujo la posibilidad de encontrar individuos resistentes a la Escoba de Bruja, especialmente en el grupo del complejo Trinitario. Los estudios realizados en Trinidad (7,8) y en el Ecuador (4,5) indican diferencias considerables en la susceptibilidad a la Escoba de Bruja entre clones de linaje Trinitario. Las exploraciones de Pound (9,10) indicaron que la resistencia a la Escoba de Bruja reside en la línea Forastero Amazónica y también que el Valle del Amazonas comprende el centro de origen de la especie Theobroma cacao. En vista de que una parte del Valle superior del Amazonas se encuentra dentro de la República del Ecuador, se creyó a bien investigar esa zona a fin de recolectar cacao resistente a la Escoba de Bru

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* Una contribución de la Estación Experimental Tropical de Pichilingue sostenida por el Servicio Cooperativo Interamericano de Agricultura mediante un convenio especial entre los E.E.U.U. y el Ecuador.

** Fitopatologo y Director de la Estacion Experimental Tropical de Pichilingue, Ecuador

*** Antes Jefe del Departamento de Fitopatología, USOM/Ecuador y actualmente Asesor en Cultivos Tropicales USOM/Costa Rica.

Este trabajo presenta los datos sobre el comportamiento de los es Silecia-1 y 5 recogidos en una expedición efectuada al Río Na- n 1949 por Desrosiers y von Buchwald (2). Ademas se incluyen los s de la progenie de cuatro cruces interclonales, en que se usaron clones Silecias como padres.

EXPEDICIONES EFECTUADAS ANTERIORMENTE AL AMAZONAS

Pound (9,10) recorrió el Valle del Amazonas en los sectores de dor, Perú y Colombia, encontrando gran variedad de tipos de cacao. scoba de Bruja estaba bien distribuida por los sitios que visitó. d recogió material aparentemente resistente a la enfermedad y lo acho a Trinidad. Las Plantas fueron observadas por muchos años y ncontró que algunos árboles mostraron muy alta resistencia a la Es- de Bruja, de manera especial los clones designados como SCA-6 y 12.

En 1949 Desrosiers y von Buchwald (2) viajaron por la región del Napo en el Oriente Ecuatoriano, con el objeto de recoger material stente a la Escoba de Bruja. El proyecto de viaje fue bajar desde abecera del Río Napo hasta Rocafuerte en la frontera peruana. Los dicionarios recogieron yemas de árboles que no presentaron síntomas scoba de Bruja, a pesar de estar rodeados de árboles fuertemente ata- s. La colección mas valiosa se efectuó en la Hacienda Silecia, en ecindad de Archidona, situada aproximadamente 1° 54' de Latitud y 77° 49' Longitud Oeste. En total, Desrosiers y von Buchwald re- eron 30 selecciones de cacao. El material recogido fue injertado en ones ubicados en una plantación de cacao con severa incidencia de scoba de Bruja en la Estación Experimental Tropical de Pichilingue.

Doak y otros colaboradores (6) en 1958 regresaron a Archidona con bjeto de observar el material original recogido por Desrosiers en da. Silecia, pero se encontró que casi todas las plantas señaladas an sido eliminadas. Se recogieron yemas de un árbol que no presen- íntomas de la Escoba de Bruja, y fueron despachadas a la Estación rimental de Pichilingue.

COMPORTAMIENTO DE LOS CLONES SILECIA-1 Y 5

En el registro de los datos de las selecciones recolectadas en el Napo, se destaca el comportamiento de los arboles Silecia-1 y Sile- 5, por presentar una alta resistencia a la Escoba de Bruja. En la alidad los arboles tienen 10 años de edad. En el cuadro No. 1 se tran los datos de infección de Escoba de Bruja en brotes vegetativos,

Cuadro No. 1 Datos de infección con la Escoba de Bruja registrados en los árboles

Clon	No. de árboles	Promedio de escobas por árbol											
		Vegetativas				Cojinetes				Infección en la mazorca			
		1956	1957	1958	1959	1956	1957	1958	1959	1956	1957	1958	1959
Silecia-1	6	2.1	3.5	0.1	2.1	0.1	0.8	0.8	0	0.5	0.6	3.0	0.6
Silecia-5	4	1.5	1.0	0	0.7	0.2	1.2	0	0	0.5	0	0	0
SCA-6	5	1.4	2.8	3.0	9.0	-	-	-	6.8	-	-	-	1.2
SCA-12	5	0.8	0	0.4	7.0	-	-	-	2.2	-	-	-	0.4
ICS-1	49	3.6	8.4	240.7	63.5	-	-	-	130.1	-	-	-	1.3

inetes florales e infección en las mazorcas en los clones mencio-
os. También se presentan los datos de infección de M. perniciosus
istrados en los clones SCA-6, SCA-12 e ICS-1, con el objeto de
parar la incidencia de la Escoba de Bruja en clones conocidos. Es
señalar que con estos últimos clones no se tomaron datos de infec-
n en cojinetes y en mazorcas de 1956 a 1958.

Se puede observar en el cuadro No. 1 que la incidencia de la
oba de Bruja fué menor en los clones Silecia-1 y 5 en comparación
los clones SCA-6, SCA-12 e ICS-1. Los árboles del clon Silecia-5
istraron menor número de escobas que los árboles del clon Silecia-1.
datos presentados de infección con la Escoba de Bruja en el clon
-1 muestran la incidencia de la enfermedad en un clon conocido.

En el cuadro No. 2 se muestran los datos de producción, índices
semilla y mazorcas de los clones Silecia-1 y Silecia-5. El número
mazorcas cosechadas en el período de 1956 a 1959 fué muy reducido.
mencionados clones tienen muy buen índice de mazorca, de 5.8 y
, y los índices de semilla registrados de 2.4 y 2.8 son realmente
ables.

dro No. 2 Datos de producción, índices de mazorca e índice de semillas de los clones Silecia-1 y 5

on	No. de árboles	No. de mazorcas cosechadas 1956-1959	Indice de mazorcas*	Indice de semillas**
lecia-1	6	101	5.8	2.8
lecia-5	4	64	6.0	2.4

Número de mazorcas necesarias para producir una libra de cacao se-
co.

Promedio de peso seco en gramos de las almendras.

ALGUNAS CARACTERISTICAS DE LOS CLONES SILECIA-1 Y 5

Las mazorcas de los árboles Silecia cuando maduras tienen un co-
amarillo y cuando están tiernas el color es verde, la superficie
verrugosa, brillosa, con surcos profundos. La base de la mazorca
profunda, el extremo puntón, a veces redondeado. En el clon Sile-
-1 se promediaron las siguientes dimensiones de la mazorca: largo
3 cm, y ancho 9.2 cm. En el clon Silecia-5 se registraron: largo
6 cm, y ancho 8.7 cm. El grosor de la cáscara varía de 0.6 a 1.5

Las semillas son grandes, puntonas, de color morado claro a obscuro. El número de semillas encontrados en las mazorcas varía de 20 a 49, siendo el promedio de 30 semillas. Las flores son grandes, de color verde claro, el pedúnculo floral es color verde claro como en los Scavina, la brotación de hojas jóvenes es de color verde. Las ramillas de los mencionados clones son difíciles de enraizar, y la mejor propagación de este material se obtuvo por injerto de yema. En autopolinizaciones realizadas, se determinó que el clon Silecia-1 es auto-incompatible, aún no se ha determinado si el clon Silecia-5 también es auto-incompatible. En esta época del año no han producido suficientes flores para determinar esta característica.

VARIABILIDAD DE LA PROGENIE DE CUATRO CRUCES EN QUE SE UTILIZARON LOS CLONES SILECIA-1 Y 5 COMO PADRES

El cuadro No. 3 muestra los datos de variabilidad de la progenie de cuatro cruces, en que se utilizaron los clones Silecia-1 y 5 como padres. La progenie de los cruces se origina de mazorcas de polinización abierta de los clones Silecia-1 y 5. Los otros dos cruces fueron efectuados con SCA-6 y un clon local. El cuadro No. 3 resume los datos de infección de la Escoba de Bruja y en el cuadro No. 4 se muestra la variabilidad de rendimiento e índice de mazorca de la progenie de los cuatro cruces mencionados.

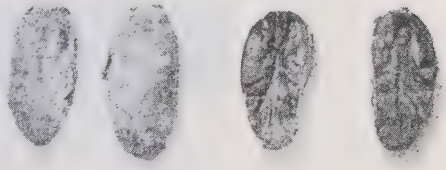
Un examen de las características de la progenie de cuatro cruces interclonales revela una alta resistencia a la Escoba de Bruja cuando se utilizan los clones Silecias como padres. De manera especial, en la progenie del cruce SCA-6 x Silecia-1, se seleccionó un individuo para usarse como clon, por tener alta resistencia a Escoba de Bruja y buenos índices de mazorca y semilla (1).

Lamentablemente no se conocen los otros padres de las progenie de polinización abierta de los clones Silecia-1 y 5, pero se nota alta resistencia en la progenie. Los índices de mazorcas en estos cruces son buenos.

Mazorcas de Silecia No. 1

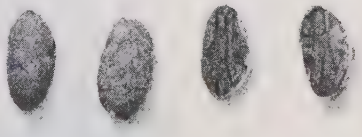
Mazorcas de Silecia No. 5

SILECIA Nº 5

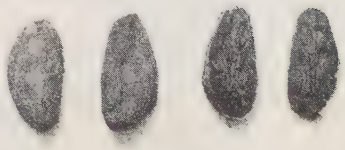


SILECIA Nº 1

SCA 6



SCA 12



Almendras de Silecia Nos. 1y5, de SCA 6 y 12

Cuadro No. 3 Datos de variabilidad en infección de Escoba de Bruja en cuatro cruces interclonales en que se usaron los clones Silecia 1 y 5 como padres. 1955 a 1958 x

Cruce	No. de plantas	Escobas Vegetativas			Escobas en Cojinetes			Infección de Mazorcas		
		Promedio árbol/año	Coef. de variación anual	Rango anual promedio	Promedio árbol/año	Coef. de variación anual	Rango anual promedio	Promedio árbol/año	Coef. de variación anual	Rango anual
Silecia-1 x SCA-6	28	0.15±0.06	40%	0-1.5	0.04±0.01	35.7%	0-0.2	0.04±0.01	25%	0-0.2
Silecia-1 x 192	18	0.13±0.1	33.3%	0-2	0.12±0.07	58.3%	0-1.2	0.0 ±0.005		0-0.2
Silecia-1 (polinización abierta)	74	2.0± 0.3	15.0%	0-12.6	3.6 ±1.0	27.7%	0-53.6	21.34±7.1	33.3%	0-432.3
Silecia-5 (polinización abierta	25	1.4 ±0.04	28.5%	0-11.3	0.1 ±0.05	50.0%	0-1.3	0.02±0.01	50.0%	0-0.3

x/ Los datos que se presentan son el promedio anual por árbol para cada cruce.

Cuadro No. 4 Variabilidad de rendimiento e indice de mazorca en la progenie de cuatro cruces interclonales en que se usaron los clones Silecia-1 y 5 como padres. 1955-1958

Cruce	No. de árboles	Rendimiento			Indice de mazorca		
		Promedio grms. cacao seco	Coef. de var.	Rango	Promedio grms. cacao seco	Coef. de var.	Rango
Silecia-1 x SCA-6	28	200.38 ±46.5	23.2%	0 - 972	8.11± 0.3	4.5%	6.74 - 9.67
Silecia-1 x 192	18	26.0 ± 9.6	36.7%	0 - 147	11.2 ± 0.8	7.1%	8.77 -12.6
Silecia-1 (Polinización abierta)	74	521.9 ±75.9	14.5%	0 -2820.2	8.1 ± 0.27	3.2%	5.9 - 12.6
Silecia-5 (Polinización abierta)	25	52.8 ±17.8	33.6%	0 - 312.2	6.0 ± 0.4	8.1%	4.7 - 7.69

x/ Los datos que se presentan son el promedio anual y por árbol

DISCUSION

En la actualidad los clones SCA-6 y SCA-12 representan el mejor rial disponible en resistencia a la Escoba de Bruja. Estos clo- tienen la desventaja de tener un alto índice de mazorca y un ta- pequeño de semilla. Los clones Silecia-1 y 5 recogidos por Des ers y Von Buchwald en el Río Napo, además de tener alta resisten a la Escoba de Bruja, tienen muy buenos índices de mazorca y se- a. De acuerdo con los datos registrados parece que el clon Sile 5 tiene mayor resistencia a la Escoba de Bruja que el clon Sile 1. Estos clones podrían usarse en programas de hibridaciones in lonales.

A pesar de que no se hicieron inoculaciones artificiales con es s de Marasmius perniciosus, los árboles estaban colocados en con ones muy favorables para la inoculación natural, al estar rodea- de árboles fuertemente atacados con la Escoba de Bruja. Es nece o continuar investigando las cualidades de resistencia a la Esco e Bruja de estos clones, de manera especial bajo condiciones eco cas diferentes a las que prevalecen en Pichilingue. También es sario determinar la calidad comercial de la almendra, la compati dad, y otras características.

Los datos presentados confirman el inmenso valor de las expedi- es al Amazonas. Se impone la necesidad de efectuar más viajes a región, recorrer otra vez el Río Napo, también la región del Napo- aza, al Sur de la región de los Jíbaros, como fué sugerido por osiers.

RESUMEN

Se presentan los datos de infección de Escoba de Bruja en los clones Silecia-1 y Silecia-5 registrados de 1956 a 1959. Estos clones fueron seleccionados en la región del Río Napo en 1949.

Se compara la incidencia de la Escoba de Bruja de los clones Si lecias con los clones conocidos de alta resistencia, SCA-6 y SCA-12, y el clon ICS-1. Los clones Silecias presentaron menos infección que los Scavinas. El clon Silecia-5 tuvo menos Esco- bas que el clon Silecia-1.

También se presentan los datos de variabilidad en resistencia a la Escoba de Bruja, índices de mazorcas y de semilla de la pro- genie de cuatro cruces en los que se utilizaron los clones Sile cias como padres. La progenie de dos cruces proviene de polini zación abierta de los clones Silecia-1 y 5.

Se recomienda efectuar otras expediciones al Amazonas.

SUMMARY

1. Data of infection with Witches' Broom from 1956 to 1959 for clones Silecia-1 and Silecia-5 are presented. The clones were selected in the Rio Napo area in 1949.

2. The incidence of Witches' Broom in the Silicia clones is compared with clones SCA-6 and SCA-12, known to be highly resistent, and with ICS-1. The Silecia clones showed less infection than the Scavinas, and Silecia-5 had less infectio than Silecia-1.

3. Data on the variation in resistance to Witches' Broom and po and seed indices are presented for four crosses made using t Silecia clones as parents, two of them arising from open pollination.

4. Further expeditions to the Amazon area are recommended.

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PROGRESOS ALCANZADOS EN EL ECUADOR EN EL ESTUDIO DE SELECCION PARA RESISTENCIA A LA ESCOBA DE BRUJA*

Enrique Ampuero**

INTRODUCCION

La Escoba de Bruja causada por el Marasmius perniciosus Stahe (Crinipellis perniciosus Singer) es una de las enfermedades que a- nualmente causa más pérdidas a la producción cacaotera ecuatorian. El programa de selección de cacao para resistencia a la Escoba de Bruja se inició en 1949 basado en la heterogeneidad genética del cacao: esta variación permite seleccionar individuos resistentes a la Escoba de Bruja. Las investigaciones efectuadas en el Ecuador por Desrosiers (2) indican que el cacao nacional, nativo del Ecua- posee poca resistencia a la Escoba de Bruja, mientras que se enco- tró gran variación en resistencia en el cacao trinitario introduc- do al Ecuador.

Miles de plantitas de semillas provenientes de diferente ori- gen se sometieron a condiciones severas de infección. Se colocar- plantas en camas bajo sombras de árboles fuertemente atacados por la Escoba de Bruja y mensualmente se hicieron inoculaciones con suspensiones de esporas de Marasmius perniciosus. Las plantas qu mostraron síntomas de Escoba de Bruja se eliminaron, finalmente sobrevivieron 752 plantas que se sembraron en el campo en 1952 y 1953, regularmente se ataban a los árboles las Escobas que se pro- dujeron con el objeto de proporcionar nuevas fuentes de inóculo.

En 1952 Desrosiers y von Buchwald (1) hicieron una expedició- a lo largo del Río Napo con el objeto de recoger material resiste- a la Escoba de Bruja. Se recogieron varetas de árboles que no pre- sentaron Escobas a pesar de estar rodeados por árboles fuertement- atacados. Se tomaron yemas de este material, se injertaron en chu- pones de árboles de la Estación Experimental y se colocaron bajo - servación.

En 1955 Desrosiers y Díaz (4) hicieron una evaluación prelim-

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* Contribución de la Estación Experimental Tropical de Pichilingu sostenida por el Servicio Cooperativo Interamericano de Agricul- tura mediante un convenio especial entre los Estados Unidos y Ecuador.

** Fitopatólogo. Director de la Estación Experimental Tropical d Pichilingue.

las plantas en observacion para resistencia a la Escoba de Bruja; selecciones mantuvieron una relación Escoba-edad* no mayor de . Durante 1953 a 1954, 397 selecciones mantuvieron una relación oba-edad no mayor de 1,5 y 323 selecciones registraron sólo una oba.

EVALUACION DE LAS SELECCIONES PARA RESISTENCIA A LA ESCOBA DE BRUJA

Los datos de los árboles en observación indican que durante el íodo de 1953 a 1958 hay 64 árboles que no han registrado nunca obas vegetativas ni infección en la mazorca. La mayor parte de os árboles produjeron poco y tienen un índice de mazorca** muy o. Hay un grupo de 368 árboles que tiene una relación promedial oba-edad de 1 durante el período de 1956 a 1958. La mayor parte estos árboles ha producido muy poco y tiene un índice de mazor- de más de 9, algunos de los árboles son pequeños y raquíticos crecer en malas condiciones de suelo.

Con el objeto de seleccionar un grupo de árboles que tenga al- resistencia a la Escoba, bajo índice de mazorca y buen rendimien- para ser propagado como clones se usó el siguiente criterio de sificación. Se consideró una selección con alta resistencia a oba de Bruja si durante el período de 1953 a 1958 mantuvo una re- ión Escoba-edad promedial no más de 1 e índice de mazorca no más 9. La observación del rendimiento anual de árbol se consideró o como indicio de buen productor, porque se trata de un solo ár- , es posible que con condiciones particulares de suelo estén in- yendo en el rendimiento del árbol.

El cuadro Nº 1 presenta la relación Escoba-edad de 4 árboles eccionados para usarse como clones.

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*La relación Escoba-edad es un índice que resulta de dividir el número total de Escobas producidas por un árbol en un año para la edad. Desrosiers (2).

**Indice de mazorca es el número de mazorcas necesario para pro- ducir una libra de cacao seco. Se considera que un árbol que necesite más de 9 mazorcas para producir una libra de cacao se- co no es aceptable, a menos que tenga otras características so- presalientes.

Cuadro Nº 1. Relación Escoba-edad de 4 árboles seleccionados para usarse como clones

Denominación original	Denominación actual	Edad a 1958	Relación Escoba-edad				
			1954	1955	1956	1957	1958
7438	EET 397	9.0	0	0	2.0	0	0
7818	EET 400	6.9	0	0	0	0.3	1.1
7811	EET 399	6.9	1.8	0	0.2	0.8	0
7419	EET 404	9.7	0	2.2	0	0.5	1.2

Los árboles 7811 y 7818 provienen de polinización abierta del árbol Silecia No. 1 traído por Desrosiers en su expedición al Río Napo (1). Los árboles 7419 y 7438 son trinitarios.

Los cuadros 2 y 3 resumen los datos de rendimiento, índice de mazorca y peso de semilla de los 4 árboles seleccionados.

Cuadro Nº 2. Rendimiento de los árboles seleccionados durante el período de 1955 a 1958

Denominación original	Denominación actual	Producción anual en libras de cacao seco			
		1955	1956	1957	1958
7438	EET 397	0.96	1.24	4.85	6.31
7818	EET 400	----	0.32	2.54	4.03
7811	EET 399	0.83	1.93	3.45	9.26
7419	EET 404	3.12	1.81	2.64	1.12

adro Nº 3. Indice de mazorca y peso de semilla de los árboles seleccionados

nominación original	Denominación actual	Indice de mazorca	Indice de semilla grms.
7438	EET 397	6.5	1.55
7818	EET 400	8.9	1.87
7811	EET 399	8.1	1.31
7419	EET 404	6.9	1.88

En la actualidad se está propagando este material con el obje- de colocar estos nuevos clones en un experimento de comparación onal, utilizando un buen diseño experimental para averiguar con número mayor de árboles ciertas características, como rendimien- ; también se averiguará el comportamiento de estos clones en otras calidades del Ecuador.

LECCION DE ARBOLES CON CARACTERISTICAS SOBRESALIENTES DE LA PROGENIE DE HIBRIDOS INTERCLONALES EN LA ESTACION EXPERIMENTAL DE PICHILINGUE

En 1952 se inició en la Estación Experimental de Pichilingue programa de hibridaciones entre clones de alta resistencia a coba de Bruja y buena producción con el objeto de seleccionar la progenie híbrida, individuos que reunan las buenas caracte- sticas de los padres para usarse como clones. Como fuente de sistencia a la Escoba de Bruja se usaron los clones de Trinidad A 6, SCA 9, SCA 12, clones Silecia 1 y Silecia 5 recolectados r Desrosiers en su expedición al Río Napo. Además se utilizaron ros clones seleccionados en el Ecuador por Fowler (5) para pro- cción y resistencia a la Escoba de Bruja.

En el cuadro Nº 4 se indican la relación Escoba-edad de los jores árboles seleccionados de la progenie de los cruces inter- onales efectuados. Para seleccionar se siguió el mismo criterio dalado anteriormente en lo concerniente a resistencia a la Escoba Bruja, índice de mazorca y rendimiento.

Cuadro Nº 4. Relación Escoba-edad de los árboles seleccionados de la progenie híbrida de los cruces interclonales

Denominación original	Denominación actual	Edad a 1958	Relación Escoba-edad				Cruce
			1955	1956	1957	1958	
2270	EET 392	5.6	0	0	0	0	Silecia Nº SCA 6
1832	EET 377	6.4	0	0	0	0	156 x SCA 6
1674	EET 373	6.4	0.2	1.5	0.5	0.1	SCA 6 x 224
1800	EET 374	6.4	0.2	0.2	0.5	0	62 x SCA 6
1972	EET 382	6.3	0	0.2	0.1	0	156 x SCA 9
2015	EET 385	6.3	0.6	0	0	0	SCA 12 x 48
2022	EET 386	6.3	0.2	0	0.3	0	SCA 12 x 48
2128	EET 388	6.6	0	0.5	0.9	0	238 x SCA 1
2159	EET 389	6.6	0.3	0	0	0.2	238 x SCA 1
2166	EET 390	6.6	0	0	0.8	0.4	238 x SCA 1
2190	EET 391	6.6	0	0.6	0	0	238 x SCA 1
2528	EET 393	6.0	0	0.3	0	0	250 x SCA 6
2554	EET 394	6.0	0	0	0	0	250 x SCA 6

En el cuadro Nº 5 se resumen los datos de producción, índice de m
zorca y peso de semilla de los árboles seleccionados.

adro Nº 5. Datos de producción, índice de mazorca y peso de semilla de los árboles seleccionados de la progenie híbrida

nominación original	Producción en libras de cacao seco* 1956	1957	1958	Indice de mazorca	Indice de semilla
2270 (X)	----	0.34	4.45	6.77	No determinado
1832 (X)	2.50	2.78	1.30	6.97	1.41
1674	2.85	7.08	2.68	6.91	1.77
1800 (X)	2.92	1.39	3.99	7.37	1.27
1972 (X)	5.45	1.86	1.92	7.47	1.53
2015 (X)	0.81	1.95	0.83	8.24	1.31
2022 (X)	3.04	2.90	2.06	8.54	1.37
2128 (X)	3.74	3.37	8.83	8.11	1.74
2159 (X)	1.32	2.04	2.97	7.82	1.40
2166	4.38	4.32	9.58	7.73	1.43
2190 (X)	1.01	1.31	0.97	7.73	2.00
2528 (X)	0.37	0.52	1.97	7.81	1.61
2554 (X)	2.20	1.68	1.60	7.95	1.34

lo hay registro de datos desde marzo hasta setiembre de 1958 en os árboles marcados (X).

DISCUSION

Los datos presentados indican que en el Ecuador existe actualte muy buen material para un programa de mejoramiento de cacao; dispone de clones con alta resistencia a la Escoba de Bruja, n índice de mazorca y semilla. Todos los clones seleccionados nen un índice de mazorca que oscila entre 6 y 9; el índice de illa en todos los casos es más de 1 gramo de cacao seco; estos tores se consideran muy importantes comercialmente. El más

alto índice de semilla de 2 gramos es del clon 391, aún no hay d
tos completos sobre el índice de semilla del clon EET 392, pero
índice de mazorca es muy bueno.

Lamentablemente los datos de producción sólo sirven como in
cación porque son datos de árboles individuales. Es necesario re
pilar información en el futuro sobre el rendimiento de estos nue
clones en un experimento diseñado con un buen número de repetici
nes, así como determinar el comportamiento de estos clones bajo c
diciones ecológicas diferentes a Pichilingue. El grupo de árbol
que tienen alta resistencia a Escoba pero que no tienen otras ca
racterísticas deseables es una buena fuente de germoplasma de re
sistencia a la Escoba de Bruja, útil para trabajos futuros.

En el programa de investigación futuro se investigarán otra
características de nuevos clones, como cualidad de fermentación,
índice de grasa, facilidad de enraizamiento y auto-incompatibili
entre otras características.

RESUMEN

Se informa de los progresos alcanzados en el Ecuador en el
programa iniciado en 1949 de selección para resistencia a la Es
de Bruja. Miles de plantitas provenientes de semilla se someti
a condiciones severas de infección. Las plantas que mostraron s
tomas de Escoba de Bruja se eliminaron y se sembraron en el cam
las plantas sobrevivientes. Finalmente se han seleccionado 17
boles para ser propagados como clones por haber mostrado alta r
sistencia a la Escoba de Bruja y buenos índices de mazorca y se
lla.

Hay un grupo de 64 árboles que hasta ahora no han registra
Escobas, este material servirá como germoplasma para trabajos f
ros. 368 árboles tienen una relación Escoba-edad promedial de 1
para el período de 1956 a 1958. Los índices de mazorca y semil
no son buenos en estos árboles, los cuales crecen raquíticos en
las condiciones de suelo.

Los datos de rendimiento presentados sólo sirven de indica
ción porque provienen de árboles individuales; es necesario inv
tigar en el futuro el comportamiento de los nuevos clones en ex
rimentos diseñados y colocados bajo diferentes condiciones ecol
gicas.

SUMMARY

The progress made in Ecuador in the selection program for ches' Broom resistance, begun in 1949, is reported. Thousands seedling plants were subjected to severe infection conditions, the plants showing severe symptoms were eliminated and the ainder planted in the field. 17 of these were finally selected propagation in clones on the basis of a high degree of resistance good pod and bean indeces.

64 trees which have so far not produced any brooms will be used future breeding work. 368 trees have a "broom-age" index of 1 the period 1956-1958. Pod and bean indeces of these clones are d, but many are planted in poor soil.

The yield data presented can only give preliminary indications hey refer to individual trees. It remains to test the selections field experiments under varying environmental conditions.

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VARIACION [illegible] RESISTENCIA A LA ESCOBA DE BRUJA, RENDIMIENTO E INDICE DE MAZORCA EN LA PROGENIE HIBRIDA INTERCLONAL *

Enrique Amposro ** y Ricardo Alvarado ***

INTRODUCCION

En los últimos años ha habido un creciente interés en la propagación de cacao por semilla, debido a las últimas informaciones provenientes de Trinidad. Cuando se cruzan algunos clones que poseen características de alta resistencia a Escoba de Bruja con otros de alto rendimiento y buen tamaño de mazorca, la progenie resultante tiene alta resistencia a Escoba de Bruja ya que 2 o más genes están involucrados en la herencia y el rendimiento en algunos casos es superior al de los padres; es indudable que la propagación de cacao por este medio resulta sencilla y bastante económica.

Los programas controlados de hibridaciones se iniciaron en Trinidad en 1949 y en Ecuador en 1952. Como fuente de resistencia a Escoba de Bruja se utilizaron en ambos países clones Scavina seleccionados por Pound (6), (7), principalmente SCA-6 y SCA-12. Además de este material, en Ecuador se utilizaron selecciones locales.

Las informaciones preliminares sobre el comportamiento de las progenies híbridas en resistencia a Escoba de Bruja, indican que hay diferencias entre las progenies provenientes de padres SCA-6 y SCA-12 (2), (8) y probablemente explicable por las diferencias en la constitución genética de las selecciones mencionadas como lo demostró Holliday (5). El informe de Bartley (2) indica que la incidencia de Escoba de Bruja fue menor en los cruces ICS-1 x SCA-6, ICS-6 x SCA-6 e ICS-60 x SCA-6.

Rubio y colaboradores (8), informaron sobre el comportamiento de la progenie de 4 cruces. Se utilizaron los clones SCA-6 y SCA-12

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** Fitopatólogo. Director de la Estación Experimental Tropical de Pichilingue.

*** Estudiante egresado, becado por el American Cocoa Research Institute.

mo padres de alta resistencia a Escoba de Bruja y los clones lo-
les EET-6, EET-48 y EET-238 y el clon EET-248 introducidos de
lombia. Los resultados de estos cruces mostraron una amplia va-
ación en la progenie. En el caso del cruce EET-6 x SCA-6 el pro-
dio de producción de la descendencia superó al del clon EET-6
nsiderado como buen productor.

En el presente trabajo se presentan los datos de variación en
ndimiento, incidencia a Escoba de Bruja e índice de mazorca * de
progenie de 62 cruces efectuados en la Estación Experimental Tro-
cal de Pichilingue.

PROCEDIMIENTO Y MATERIAL USADO EN LAS HIBRIDACIONES

El programa de hibridaciones se inició en 1952 en la Estación
perimental, en total se efectuaron 62 cruces. La mayor parte de
s cruces se hicieron con padres Scavinas como fuente de resisten-
a a Escoba de Bruja. Estos clones se cruzaron con selecciones lo-
les de alta producción, introducciones de otros países y las selec-
ones Silecias 1 y 5 recolectadas por el Dr. Desrosiers en la región
l Río Napo (3). En algunos casos se efectuaron cruces en 2 direc-
ones, es decir, usando el clon SCA-6 como padre o madre; también se
cieron unos pocos cruces fraternales.

Las progenies de estos cruces están compuestas por un número
y variable de individuos. Las plantas se sembraron en líneas a dis-
ncias de 4 x 5 metros ubicados en varios sectores de la Estación
perimental. Muchos árboles crecen bajo sombra ligera de Leucana
auca, otros árboles no tienen sombra. Las condiciones de fertili-
d de los suelos son variables, no se ha efectuado aplicación regu-
r de fertilizantes. En la actualidad las progenies tienen entre 7
8 años. El cuadro No. 1 (apéndice) indica el origen de las selec-
ones usadas en las hibridaciones.

ARIACION DE RENDIMIENTO E INDICE DE MAZORCA EN LA PROGENIE HBRIDA

Los datos de variación en rendimiento e índice de mazorca en la
ogenie de 62 cruces efectuados indican una amplia variación de es-
s características en la progenie, en muchos árboles la producción
é nula.

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* Es el número de mazorcas necesario para formar una libra de cacao
seco.

En el cuadro No. 2 se presentan los cruces que produjeron 1 a 1½ libras de cacao seco, promedio anual, por árbol.

Hay 5 cruces que produjeron más de 1½ libras, y 8 más de 1 libra de cacao seco, promedio por árbol.

En estos cruces las desviaciones alrededor del promedio son pequeñas, como lo indican los coeficientes de variación calculad En casi todos los cruces mencionados, el índice de mazorca es de más de 9, excepto el cruce EET-161 x SCA-9, que tiene un índice mazorca de 8.3. Los cruces que se indican en el cuadro No. 3 presentan índices de mazorca menor que el promedio aritmético de los padres.

Con el objeto de averiguar si habia alguna tendencia de aum to de produccion cuando se usaban clones Scavinas o selecciones locales, se agruparon los cruces que tenian padres de los origen mencionados. En el cuadro No. 4 (apéndice) se presenta el resum de rendimientos.

Es interesante notar que el grupo de cruces con padre SCA-9 muestra el más alto promedio de rendimiento.

Probablemente se explica la amplia variación en la mayor pa de los cruces efectuados a causa de la segregación en la progeni de la característica de auto-incompatibilidad proveniente de an cesores autoincompatibles como los Scavinas. Los datos de rendi miento mostrado sólo sirven como indicación porque las progenies estuvieron colocadas bajo un diseño experimental con un suficien número de repeticiones.

VARIACION EN RESISTENCIA A LA ESCOBA DE BRUJA EN LA PROGENIE HIB

Los datos de infección vegetativa, infección en cojinete y mazorcas registrados en la progenie híbrida se resumieron en el cuadro No. 5 (apéndice) agrupando las progenies que tuvieron com padres los clones SCA-6, SCA-9, SCA-12. También se agruparon la progenies de cruces efectuados entre selecciones locales y en úl timo grupo de cruces provenientes de padres introducidos de vari países.

Es interesante observar en el cuadro No. 5 que los cruces en- selecciones locales muestran la más baja incidencia de Escoba Bruja, aún la infección es más baja que las progenies con padres -6. Esto se explica seguramente porque las selecciones locales ron hechas en base a resistencia a Escoba de Bruja, entre otras acterísticas buscadas. Fowler (4) indica que este material se olectó en varias zonas cacaoteras del Litoral Ecuatoriano.

La más alta incidencia de Escoba de Bruja se produjo en los ces con antecesor SCA-9. Los datos presentados indican una am- a variación en la progenie como se puede observar por los coe- ientes de variación calculados.

CONCLUSION

Los datos registrados indican que se produce una amplia varia- n en la progenie cuando se hibridan dos clones determinados. o se explica lógicamente por la heterogeneicidad genética del ca- . En algunos cruces, la progenie alcanza un valor intermedio en- los padres en rendimiento e índice de mazorca. En la mayor par- de los casos las progenies heredan la alta resistencia a Esco- de Bruja proveniente de los padres resistentes usados.

Si se toman en cuenta las siguientes consideraciones: alta re- tencia a Escoba de Bruja, índice de mazorca no más alto que 9 endimiento no menor de 1 libra de cacao seco por árbol, los si- entes cruces presentan progenies superiores. En estos cruces los ficientes de variación calculados son bajos:

1. SCA-6 x EET-62
2. SCA-12 x EET-6
3. SCA-12 x EET-48
4. SCA-12 x EET-238
5. SCA-6 x ICS-1
6. SCA-6 x EET-156

Es importante señalar que de estos cruces se han seleccionado oles con caracteristicas sobresalientes para usarse como clones los futuros programas de mejoramiento (1).

Los datos de rendimiento presentados deben tomarse como una in- ación preliminar, porque las progenies observadas fueron sembradas hileras y no estuvieron colocadas bajo un buen diseño experimental.

Algunas progenies híbridas muestran alta resistencia a Escoba de Bruja, pero los índices de mazorcas son elevados y el rendimiento es muy bajo.

PERSPECTIVAS FUTURAS DEL PROGRAMA DE HIBRIDACIONES

Es indudable que en la Estación Experimental Tropical de Pichilingue existe un valioso material para los programas de mejoramiento de cacao, como consecuencia de selecciones locales de árboles sobresalientes e introducciones de otras localidades.

Es necesario repetir las mejores combinaciones clonales bajo un mejor diseño experimental de igual manera que las progenies con pocos árboles sobresalientes. Se puede usar la técnica descrita por Holliday (5) para eliminar los individuos más susceptibles. Es necesario efectuar también algunos cruces fraternales para fijar mejor las características deseables. Dentro de las progenies de los mejores cruces se pueden seleccionar individuos sobresalientes para usarlos como nuevos clones.

En los mejores cruces mencionados, es necesario determinar otras características, como autocompatibilidad, calidad y peso de la almendra, etc. Los mejores cruces interclonales deberían repetirse bajo condiciones ecológicas diferentes de Pichilingue con el objeto de acumular más información sobre el comportamiento de las progenies.

RESUMEN

En 1951 se hicieron cruzamientos controlados entre clones resistentes a Escoba de Bruja y clones de altos rendimientos. En 19 se plantaron en el campo hileras continuadas con un número variabl de plantas de 62 combinaciones híbridas interclonales.

Los cruzamientos entre clones ecuatorianos, uno de ellos sien de alta resistencia, fueron los más resistentes a la Escoba de Bru pero mostraron los rendimientos más bajos. Los cruzamientos que tenían SCA-9 como uno de los padres fueron los más susceptibles, pero mostraron los rendimientos más altos.

Las combinaciones híbridas seleccionadas como las más promiso fueron SCA-6 x EET-62, SCA-12 x EET-6, SCA-12 x EET-48, SCA-12 x EET-238, SCA-6 x ICS-1 y SCA-6 x EET-156. Se ha seleccionado algu árboles dentro de estas progenies para ser propagados y probados c clones en un ensayo de campo.

SUMMARY

Controlled crosses were made in 1951 between clones that were istant to Witches' Broom caused by Marasmius perniciosus Stahel clones which were high in yield. The seed of 62 interclonal rid progenies was planted in 1952 in progeny rows.

The crosses between Ecuadorian clones, one parent of which sessed resistance to Witches'Broom, were most resistant to ches'Broom but showed the poorest yield. The crosses that had -9 as one parent were the most susceptible to Witches'Broom showed the highest yield.

The hybrids selected as the most promising were SCA-6 x EET-62, -12 x EET-6, SCA-12 x EET-48, SCA-12 x EET-238, SCA-6 x ICS-1 SCA-6 x EET-156. Several trees have been selected within these genies to be propagated and tested as clones in a replicated nal trial.

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Cuadro No. 1 - Origen de los clones usados en las hibridaciones efectuadas en la Estación Experimental Tropical de Pichilingue.

Denominación de la Estación Experimental	Procedencia	Origen
EET-6	Ecuador Pichilingue, Prov. Los Ríos	C2-Tr.886
" 11	Trinidad	SCA-6
" 12	Colombia	C2-Tr.886
" 48	Ecuador	Sta. Rosa 3
" 49	Ecuador " "	Sta. Rosa 3
" 50	Ecuador " "	Sta. Rosa 3
" 59	Ecuador, San Javier " "	San Javier
" 60	Ecuador, San Javier " "	San Javier
" 61	Ecuador, San Javier " "	San Javier
" 62	Ecuador, San Javier " "	Porvenir
" 78	Ecuador, Sta. Rosa " "	Sta. Rosa
" 80	Ecuador, Sta. Rosa " "	Sta. Rosa
" 82	Ecuador, Porvenir " "	Pichilingue
" 110	Trinidad	SCA-9
" 111	Trinidad	SCA-12
" 156	Ecuador, San Genaro " "	San Genaro
" 159	Ecuador, Morocho " "	Morocho
" 161	Ecuador, Curiquingue " "	Curiquingue
" 166	Ecuador, San Carlos " "	San Carlos
" 174	Ecuador, Mascota " "	Mascota
" 184	Ecuador, San Juan P. " "	San Juan P.
" 192	Ecuador, Quinta Cerer " de Manabí	Quinta Cere
" 195	Ecuador, La Florida " "	La Florida
" 196	Ecuador, La Florida " "	La Florida
" 224	Ecuador, Tenguel " del Guayas	Tenguel
" 228	Ecuador, Tenguel " "	Tenguel
" 237	Ecuador, Tenguel " "	Tenguel
" 238	Ecuador, Isla Bejucal " Los Ríos	Isla Bejuca
" 248	Colombia	-
" 250	Colombia	
" 252	Ecuador, Pichilingue " "	Las Fuentes
" 262	Ecuador, Pichilingue " "	Hiler
" 270	Colombia	
" 274	Trinidad	ICS-1
" 284	Ecuador, Pichilingue " "	Pichilingue
" 309	Colombia	
" 313	Costa Rica	UF-667

Cruces	VARIACION EN LA PRODUCCION: No.de plantas	Rendimiento Prom. Grs. cacao seco	Coeficiente de variación	Rango	VARIACION DEL INDICE DE MAZORCA *: No.de plantas	Promedio	Coeficiente de variación	Rango
ET-156 x SCA-9	18	975,6 ±115,25	11,81%	526,7 -2.517,80	18	9,04±0,49	5,42%	6,26-14,85
CA-12 x EET-48	29	926,73± 98,70	10,65%	236,0 -2.236,00	28	9,51±0,26	2,73%	6,99-12,29
ET-161 x SCA-9	6	885,54± 88,70	10,01%	648,65-1.235,5	6	8,37±0,64	7,64%	6,14-10,13
ET-62 x SCA-6	21	800,61± 92,30	11,51%	255,3 -1.876,10	21	9,7 ±0,52	5,36%	6,56-16,57
CA-12 x EET-6	13	790,30±133,24	16,85%	133,20-1.414,7	12	9,73±0,59	6,06%	6,27-13,04
CA-6 x EET-6	66	681,89± 58,01	8,50%	0 -2.060,00	44	11,53±0,39	3,38%	7,02-19,35
CA-6 x EET-224	20	650,47±100,23	15,40%	19,5 -1.743,40	16	10,61±0,44	4,14%	7,22-13,88
iler** x Cacao Nacional	39	641,38± 63,78	9,94%	0 -1.583,70	32	9,18±0,32	3,48	6,81-14.08
CA-12 x EET-184	9	574,34±162,82	28,34%	22,0 -1.502,3	6	11,36±0,60	5,28%	9,49-13,35
CT-156 x SCA-6	41	522,88± 34,90	6,67%	143,40-976,20	37	9,20±0,27	2,93%	5,89-13,69
CT-248 x EET-174	37	491,21± 63,30	12,88%	41,40-1.522,6	26	10,14±0,24	2,36%	7,50-12,82
CS-1 x SCA-6	30	484,20± 77,90	16,08%	21,60-1.734,20	21	8,93±0,33	3,69%	6,18-12,76
CT-238 x SCA-12	49	471,04± 65,2	13,84%	10,40-1.868,70	32	9,56±0,30	3,1%	6,51-15,15

* El índice de mazorca se obtuvo a base de 20 a 30 mazorcas por árbol

** Se desconoce el origen

Cuadro No. 3 - Indices de mazorcas de las progenies y clones padr
de los cruces que produjeron más de 1½ lb. de caca
seco.

Progenies y Padres	Indice de Marzoca	Promedio aritmético índice de mazorca
Clon SCA-6	14.5	
Clon EET-62	8.8	
Cruce EET-62 x SCA-6	9.7	11.6
Clon SCA-12	13.0	
Clon EET-48	8.4	
Cruce SCA-12 x EET-48	9.5	10.7

Cuadro No. 4 - Resumen que agrupa los cruces efectuados según lo
padres, Scavinas, selecciones locales y clones de
diverso origen.

	Número Cruces	Número Arboles	Promedio por cruc y por árbol (grms. cacao seco
Cruces con padre SCA-6	19	519	281.12
Cruces con padre SCA-9	3	45	724.12
Cruces con padre SCA-12	10	238	427.75
Cruces con padres Locales	24	402	129.82
Cruces con clones de diverso origen	6	102	153.65

dro No. 5 - Resumen que agrupa los cruces efectuados según los padres Scavinas, selecciones locales y clones de diverso origen.

	No. Cruces	No. árboles	Escobas Vegetativas	Escobas Cojinete	Escobas Mazorcas	Suma Promedios
ces con padres -6	19	519	0.2	1.0	3.0	4.2
ces con padres -9	3	45	2.5	5.3	5.9	13.7
ces con padres -12	10	238	1.0	2.6	2.5	6.1
ces entre selec- nes locales	24	357	2.3	0.9	0.3	3.5
ces con clones origen diverso	6	102	2.7	4.9	2.0	9.6

POSIBLE EVIDENCIA DE RESISTENCIA A LA MONILIA RORERI CIF. Y PAR. EN ALGUNOS CLONES DE LA ESTACION EXPERIMENTAL TROPICAL DE PICHILINGUE*

Julio C. Delgado,** Enrique Ampuero P.,*** Kenneth D. Doak****

INTRODUCCION

La "Podredumbre Acuosa" o Monilia causada por la Monilia Rore Cif. y Par. ocasiona grandes pérdidas anuales en el Ecuador, cuyo monto no ha sido calculado con exactitud. La Monilia se ha extend do de las áreas cacaoteras del Ecuador, donde se observó por prime vez en 1916, a las regiones vecinas de Colombia, Perú, Venezuela, Panamá y hay denuncias de su posible existencia en el norte del Br (2, 3).

No se ha observado que la enfermedad afecte a parte alguna de árbol con excepción de las mazorcas y no se ha informado que ataqu a otro huésped que el cacao. Los frutos se infectan en las primer etapas de su desarrollo, posiblemente a través de entradas natural aun sin la intervención de un agente vector y las mazorcas parecen menos susceptibles con la madurez.

La enfermedad es más grave durante la época de fuertes lluvia período crítico que coincide con la época de formación de frutos. por esto que se recomienda la aplicación de fungicidas protectores ra evitar la infección de las mazorcas jóvenes.

En este trabajo se presentan datos de infección por Monilia R en 52 clones de la Estación Experimental Tropical de Pichilingue d te los años de 1956, 1957 y 1958.

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** Estudiante egresado, becado por el American Cocoa Research Institute.

*** Fitopatólogo. Director de la Estación Experimental Tropical de Pichilingue.

**** Asesor del Departamento de Fitopatología, USOM/Ecuador

REVISION DE LITERATURA

Hasta ahora todos los esfuerzos se han dirigido a encontrar un rol de la enfermedad con productos químicos que resultase efec- y económico de aplicar.

Rorer en 1918 (8) recomienda por primera vez el uso del Caldo delés 5-5-50. García y Naundorf en 1952 (5, 6) en Colombia in- an no haber obtenido resultados satisfactorios en ensayos sobre rol de la enfermedad con fungicidas, poda y eliminación de male- Las atomizaciones dieron como resultado una disminución en la ucción y aumento en la incidencia de la marchitez fisiológica de frutos.

Desrosiers y Díaz (1, 3) indicaron que la enfermedad puede ser rolada mediante la aplicación de azufre mojable, zineb, óxido oso u oxicloruro de cobre aplicados a alto o bajo volumen.

No hay evidencias de resistencia o susceptibilidad varietal en acao a la infección por Monilia Roreri. Rorer en 1918 (8) obser- ue el cacao "Venezolano"* era más susceptible que la variedad ional" del Ecuador y además encontró dos especies silvestres broma bicolor y Theobroma balaoensis fuertemente infectadas.

Naundorf (7) observó una baja incidencia de la enfermedad en taciones de tipo Criollo; también indica que los tipos Angoleta ndeamor son menos atacados que los grupos Amelonados y Calaba- o; además indica que las mazorcas de color rojo o morado son s atacadas que las de color verde o amarillo.

Díaz (4), en un estudio realizado en plantaciones de árboles itarios, encontró que la pigmentación amarilla o roja de la rca no estaba relacionada con la susceptibilidad a la infección. lmente que la situación de los árboles a sol o sombra tampoco uía en la incidencia de la enfermedad.

MATERIALES Y METODOS

Se registraron datos de infección por Monilia Roreri en 52 clo- provenientes del Ecuador y de algunas introducciones de Trinidad, mbia, Costa Rica, Brasil y Venezuela. Los datos corresponden a

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* cacao Trinitario es denominado también "Venezolano" en el Ecuador.

los años de 1956, 1957 y 1958, tiempo durante el cual los árbol estuvieron sometidos a condiciones naturales de infección y no cibieron aplicaciones de fungicidas. Los clones estudiados est bajo ensayos de comparación clonal en diseños de cuadrados lati 6 x 6 con parcelas de una sola planta a distancias de 4 x 4 me En el campo se presentan muchas fallas por lo cual el número de árboles por clon no es uniforme. La edad de los árboles varía tre 6 y 7 años.

Incidencia de Monilia en 52 clones de la Estación Experimental Tropical de Pichilingue

La infección se estimó en porcentaje, en base al número t de mazorcas producidas; el número de mazorcas cosechadas en ca clon fue variable. Los clones se ordenaron según una escala a traria, en porcentajes que varían de 0 a 20 y más y se present en el cuadro No. 1.

La precipitación pluvial, que se indica a continuación, f normal durante el tiempo en que se tomaron los datos de infec que se consignan en este trabajo.

Datos de lluvia en mm. durante los años 1956, 1957 y 1958

Año	Enero	Febrero	Marzo	Abril	Mayo	Ju
1956	364.2	384.3	582.9	616.9	53.8	2
1957	297.7	697.2	479.5	613.4	299.2	18
1958	523.2	561.8	558.0	516.6	95.2	1

Año	Julio	Agosto	Setiembre	Octubre	Noviembre	Diciem
1956	34.2	3.0	10.4	9.1	20.3	34.
1957	26.9	0.5	11.1	19.8	25.9	166.
1958	0.0	25.9	1.7	17.0	5.0	34.

Datos de 1956, 1957 y 1958

Clon Nº	Denominación original	Procedencia		Número árboles	Total mazorcas cosechadas	% Mazorcas
EET 306	Cacao House 1	Ecuador	Pichilingue (Los Ríos)	3	17	0.[illegible]
EET 36	Santa Rosa 2	Ecuador	Santa Rosa (Los Ríos)	6	115	2.60
ICS 48		Trinidad		7	77	3.09
EET 201	La María 121	Ecuador	La María (El Oro)	5	70	4.28
EET 96	Porvenir 10	Ecuador	Porvenir (Los Ríos)	6	473	4.65
EET 114	Bejucal 2	Ecuador	Isla de Bejucal (Los Ríos)	6	213	4.69
EET 24	Triunfo 11	Ecuador	Triunfo (Los Ríos)	5	122	5.73
UF 654		Costa Rica		8	121	5.78
EET 42	Santa Rosa 15	Ecuador	Santa Rosa (Los Ríos)	5	51	5.88
ICS 45		Trinidad		5	85	7.05
EET 27	Triunfo 18	Ecuador	Triunfo (Los Ríos)	6	113	7.07
ICS 40		Trinidad		6	68	7.35
SCA 6		Trinidad		6	236	7.62
EET 269		Colombia	(Valle del Cauca)	6	111	8.10
ICS 6		Trinidad		3	33	9.09
EET 26	Triunfo 15	Ecuador	Triunfo (Los Ríos)	5	156	9.61

Cuadro No. 1. (Continuación)

Clon Nº	Denominación original	Procedencia		Número árboles	Total mazorcas cosechadas	% Monilia
UF 676		Costa Rica		11	245	10.20
EET 216	Tenguel 26	Ecuador	Tenguel (Guayas)	4	106	10.37
EET 50	Santa Rosa 37	Ecuador	Santa Rosa (Los Ríos)	5	178	10.67
EET 95	Tenguel 33	Ecuador	Tenguel (Guayas)	6	282	10.88
EET 168	Cordero 1	Ecuador	Cordero (Los Ríos)	5	221	11.31
EET 19	Tenguel 15	Ecuador	Tenguel (Guayas)	6	167	11.37
EET 103	Tenguel 25	Ecuador	Tenguel (Guayas)	6	564	12.41
EET 98	Casa Grande 14	Ecuador	Clementina (Los Ríos)	6	84	13.09
SCA 12		Trinidad		6	431	15.31
ICS 8		Trinidad		5	32	15.60
EET 48	Santa Rosa	Ecuador	Santa Rosa (Los Ríos)	5	82	15.85
ICS 1		Trinidad		96	1.269	16.70
EET 90	Eden 2	Ecuador	Eden (Los Ríos)	5	174	17.81
EET 12	C-2 Tr. 886	Colombia		3	149	18.12
EET 162	Curiquingue 2	Ecuador	Curiquingue (Los Ríos)	51	4.042	18.53
EET 68	San Antonio 2	Ecuador	San Antonio (Los Ríos)	6	142	19.71
EET 21	[illegible] 30	Ecuador	Triunfo (Los Ríos)	6	40	20.00

Clon Nº	Denominación original	Procedencia		Número Arboles	Total mazorcas cosechadas	% Monilia
EET 283	Tenguel 17	Ecuador	Tenguel (Guayas)	10	230	20.86
EET 164	San Carlos 1	Ecuador	San Carlos (Los Ríos)	5	165	21.81
EET 267		Colombia	(Valle del Cauca)	2	13	23.07
UF 650		Costa Rica		6	55	23.63
EET 228	Tenguel 54	Ecuador	Tenguel (Guayas)	5	203	24.13
EET 192	Quinta Ceres 58	Ecuador	Quinta Ceres (Manabí)	4	49	28.57
EET 62	Porvenir 7	Ecuador	Porvenir (Los Ríos)	6	109	32.11
EET 212	El Vergel 203	Ecuador	El Vergel (El Oro)	12	237	32.91
EET 268		Colombia	(Valle del Cauca)	5	81	33.33
EET 38	Santa Rosa 11	Ecuador	Santa Rosa (Los Ríos)	5	32	34.37
EET 261		Brasil		9	197	36.54
EET 221	Tenguel 4	Ecuador	Tenguel (Guayas)	4	77	40.25
UF 296		Costa Rica		3	31	41.93
EET 66	Porvenir 21	Ecuador	Porvenir (Los Ríos)	6	52	42.30
EET 64	Porvenir 13	Ecuador	Porvenir (Los Ríos)	6	294	42.51
EET 308	Clementina 15	Ecuador	Clementina (Los Ríos)	4	98	43.80
EET 88	Chinquirá 2	Ecuador	Chinquirá (Los Ríos)	10	124	45.96
EET 256		Venezuela		5	173	52.60
EET 252	Las Fuentes 1	Ecuador	Pichilingue (Los Ríos)	3	37	54.05

En el cuadro No. 1 se observa que los clones EET 306, EET 36 e ICS 48 muestran los más bajos porcentajes de infección.

Es interesante observar que los clones EET 96 y EET 114, buenos productores bajo las condiciones de Pichilingue, acusan baja infección de Monilia.

También se aprecia que el clon SCA 6 se encuentra entre los clones con menos de 10% de infección. El SCA 6 es conocido por su alta resistencia a la Escoba de Bruja y utilizado frecuentemente en los programas de mejoramiento de cacao en algunos países.

CONCLUSION

Los datos presentados constituyen sólo un informe preliminar sobre posible evidencia de resistencia a la infección por Monilia Roreri en algunos clones de la Estación Experimental Tropical de Pichilingue.

La amplia diferencia en los porcentajes de infección en estos clones no muestran ninguna relación con el origen o tendencia del tipo predominante de cacao.

Los clones con más baja incidencia de Monilia representan un excelente material para futuros trabajos tendientes a la búsqueda de clones de alta resistencia al ataque de la enfermedad. Es necesario comprobar este material mediante inoculaciones artificiales con esporas de Monilia Roreri.

RESUMEN

1. Se presentan datos de infección por Monilia Roreri en 52 clones de la Estación Experimental Tropical de Pichilingue. Los datos corresponden a los años de 1956, 1957 y 1958.
2. Parece no existir relación entre la incidencia de la enfermedad y el origen o tipo de cacao.
3. Hay un grupo de 16 clones con menos de 10% de infección.
4. Se recomienda continuar investigando con este material. Hay la posibilidad de encontrar individuos con resistencia a la enferm

SUMMARY

Records for a three year period are presented on the incidence Monilia Roreri pod infection on fifty-two clones in plots under nditions of uniform exposure to natural infection and without che-cal control. The wide difference in amount of infection among ese clones did not show any relationship to origin or predominant pe tendency. Although these differences in infection incidence do t demonstrate inherent resistance, they indicate that the reaction clones to this disease should be considered as one of the charac-ristics in future selection as well as hybridization investigations.

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SUMMARY OF DISCUSSION

Dr. A.J. Hansen (IAIAS)

Do the figures shown in Table 1 for the three years show an differences in Monilia infection between the years?

Dr. E. Ampuero (Ecuador)

The rainfall differed in the different years and the incide of Monilia was in proportion to the incidence of rainfall.

TRIBUTION A L'ETUDE DES POURRITURES DES CABOSSES DU CACAOYER EN BASSE COTE D'IVOIRE DURANT LES ANNEES 1958 ET 1959

Michel Delassus, Marc Belin, et Paul Bonaventure[R]

RESUME

L'étude des pourritures des cabosses du cacaoyer commencée 958 en Basse Côte d'Ivoire a été continuée en 1959. Les ré- ats de ces deux années d'observations et de traitements sont suivants:

a) Les pertes de fruits en 1958 et en 1959 étaient inférieures aux estimations antérieures, calculées à 10-20% en 1958, et 6-8% en 1959, aproximativement.

b) Les pertes maximum de cabosses et de fruits jeunes dues au Ph. palmivora se sont notées en juillet, exactement avant la récolte principale.

c) Les chutes de pluies abondantes, un degré d'humidité relative élevé et des temperatures basses semblent favoriser la maladie. Ce n'était pas possible d'établir un ordre d'importance relative entre ces facteurs.

d) Les récoltes régulières et fréquentes diminuent les dégâts.

e) Les traitements fongicides à base de cuivre sont efficaces et les améliorations sont d'autant plus marquées que les pourritures sont nombreuses. La bouillie bordelaise était plus efficace que l'oxychlorure de cuivre et l'oxycarbonate de cuivre. Etant donné que les pertes étaient faibles, on n'a pas éstimé le coût des aspersions.

f) Les pertes dues à toutes les maladies ensembles étaient plus sérieuses durant l'époque de l'infection de Phytophthora en juin et juillet. De séptembre à mai les pertes étaient considérablement plus faibles et étaient causées par des attaques combinés de Colletotrichum, Botryodiplodia, Fusarium et insectes.

g) On a réalisé des infections expérimentales.

RESUMEN

En 1959 se continuó el estudio sobre la Podredumbre Negra de zorca del cacao el cual se inició en Basse Côte d'Ivoire. esultados de estos dos anos de observación y tratamientos son iguientes:

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re de Recherches de l'Institut Français du Café, du Cacao, d'Ivoire

a) Las pérdidas de mazorcas en 1958 y en 1959 han sido escasas e inferiores a las estimaciones anteriores; se calculan aproximadamente en 10-20% en 1958 y 6-8% en 1959.

b) Las mayores pérdidas de mazorcas y de frutos jóvenes debidos a P. palmivora ocurrieron en Junio y Julio, exactamente antes de la cosecha principal.

c) La cantidad de lluvia, el grado de húmedad relativa y las bajas temperaturas parece que favorecieron a la enfermedad. No fué posible establecer ningún órden de importancia relativa entre estos factores.

d) Las cosechas regulares y frecuentes han reducido los daños.

e) Las aplicaciones de fungicidas cúpricos fueron muy efectivas y el progreso ha sido más efectivo cuando las mazorcas infectadas eran más numerosas. El Caldo Bordelés fué más efectivo que el oxicloruro o el oxicarbonato de cobre. Como las pérdidas fueron muy escasas, no se estimó el costo de las aspersiones.

f) Las pérdidas debidas a todas las enfermedades combinadas fueron más serias durante la época de alta infección de Phytophthora en Junio y Julio. De Septiembre a Mayo, las pérdidas fueron considerablemente menores y fueron causadas principalmente por combinación de ataques de Colletotrichum, Botryodiplodia, Fusarium e insectos.

g) Se llevó a cabo inoculaciones experimentales.

SUMMARY

The research on the Black Pod disease initiated in 1958 in Basse Côte d'Ivoire has been carried on in 1959. The results of observations and control on these two years are as follows:

a) In 1958 and 1959, the damaged pods were few and their number was far under the previous estimates; they have been evaluated between 10 and 20% in 1958 and 6 and 8% in 1959.

b) The biggest losses of pods and cherelles due to P. palmivora attack occurred during June and July, just before the main harvest.

c) The amount of rainfall, the degree of relative humidity and low temperatures seemed to favour the disease. It was not possible to establish an order of relative importances among these factors.

egular and frequent cropping reduced the damage.

reatments with cupric fungicides were efficient and im-
rovement was all the more significant where the infected
ods were numerous. Bordeaux mixture was more effective
han either copper oxychloride or copper oxycarbonate.
osses having been low, the rentability of sprayings has
ot yet been established.

osses from all diseases combined were most serious during
he time of heavy Phytophthora attack in June and July.
rom September to May losses were considerably less and
ere caused mainly by a combination of Colletotrichum,
otryodiplodia, Fusarium and insect attack.

xperimental infections were carried out.

PRELIMINARY STUDIES ON THE USE OF AGRICULTURAL SPRAY OIL FOR THE PROTECTION OF CACAO AGAINST PHYTOPHTHORA PALMIVORA

Abstract*

G. Ocana** and A.J. Hansen***

INTRODUCTION

Bordeaux Mixture has so far given the best control of Phytop thora palmivora on cacao. However, its disadvantages are well kno and have frequently prevented its use on medium sized and small c cao farms. Low volume spraying with portable knapsack sprayers is gradually gaining importance in cacao and other crops. The excell results of Cercospora control in bananas by application of oil in low volume stimulated the present study. Its purpose was to eluci date the influence of oil emulsions with and without fungicides u on Phytophthora palmivora and upon Theobroma cacao. Altogether si experiments were carried out to study the different phases. The field work was carried out at La Lola farm on the Atlantic coast of Costa Rica, while the laboratory experiments took place at Tu rialba. Esso Spray Oil 35 was used in all cases.

MATERIALS AND METHODS

Experiment 1

To study the development of the fungus in the presence of o groups of flasks with PDA containing 0%, 1%, 10%, 25%, 50%, 75% 90% oil were inoculated with Phytophthora palmivora. Growth dat of the colonies were taken daily with the exception of the 90% g in which the medium was too opaque for observation. Sporulationn observed in all seven media. For pathogenicity tests, 40 cacao were inoculated, and for germination tests in oil, conidia from were placed on a 90% oil medium covered by a pure oil film.

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* Further details of this work will be published elsewhere

** Graduate Assistant, Inter-American Institute of Agricultura Science, Turrialba, Costa Rica.
Present address: c/o SCIPA, Ministry of Agriculture, Panam

*** Pathologist, Inter-American Cacao Center, Inter-American Ins tute of Agricultural Science, Turrialba, Costa Rica.

eriment 2

Clonal pods were dipped in oil - water emulsions of 10%, 25%, and 100% oil. They were then inoculated with Ph. palmivora pensions by means of a flit sprayer and incubated a) horizonly and b) vertically in cheesecloth covered propagation bins ch allowed the rain to enter. Data were taken of pod area ibily affected by the fungus.

eriment 3

To test the protective action of oil with and without fungies, groups of mature cacao pods were immersed and sprayed with ferent combinations of a series of oil concentrations, in each e with and without cuprous oxide, copper oxychloride and zinc bamate, and were later inoculated with a spore suspension. se experiments were carried out in the field as well as in a st chamber protected from rain and sun.

eriment 4

To further test the protective action of oil, groups of ng plants were sprayed with three oil concentrations with and out cuprous oxide. Another group was sprayed with Bordeaux ture. On the next day, a Ph. palmivora spore suspension was lied to the plants. 22 days later, data were taken of inted plants.

eriment 5

In order to test under field conditions the method of drop measurement developed by May (The measurement of airborne olets by the magnesium oxide method. J. Sci. Instruments 27: - 136. 1950), mass median diameter and uniformity measures were taken at various distances from a micronette low ume portable sprayer. A series of oil emulsions with and out fungicides was used for this experiment.

eriment 6

Since the spray oil applied to bananas has a certain phytoic effect, a test on cacao seemed necessary. Groups of 14 hs old plants were sprayed in low and high volume on the r and lower side of the leaf with different oil concentras with and without fungicides. Some older plants were ted in a similar way with some of the leaves exposed to the

sun and others shaded. Data were taken of visible leaf sympto

RESULTS AND DISCUSSION

As can be expected in an exploratory study of this type, the results were not in all cases conclusive. However, certain trends seem to evolve after the statistical analysis of the results:

a) The fungus grew and sporulated in oil concentrations as high as 90%, although the development was slowed down. Spores from all media were able to induce disease symptoms when inoculated on pods and were also able to germinate on a highly concentrated oil media. This indicates that the oil itself does not exhibit fungicidal or fungistatic properties, nor does it prevent spore germination.

b) Oil spray did not decrease the number of infected pods. In the group of vertical pods in the moist chamber, there was a highly significant difference in size of lesions after 8 - 16 days. Three experimental groups comprising a total of 540 pods placed vertically were analysed according to number of infected pods and according to percentage of infected pod surface. Consistently, the second criterion revealed significant differences in favor of the oil, while the first criterion did not reveal a significant difference at the 5% level, although a similar trend could be observed. However, the criterion of number of infected pods did establish the relative effectiveness of the fungicides used. Bordeaux mixture was the best, followed by cuprous oxide and then by copper oxychloride, while the zinc carbamate was not sifnificantly different from the check. The addition of oil in low concentrations augmented the effect of the low volume copp fungicides. The oil itself again did not exhibit an fungicidal properties. A possible explanation of th difference in lesion size is that the oil has a wate repellent action which retards infection.

c) Once a lesion was started, its development was not arrested by the oil. This indicates that there is no mechanism comparable to the one that arrests the growth of Cercospora in banana leaves after oil application.

d) High concentrations of oil had a definite toxic effect on both pods and leaves. This was less severe on the shaded leaves and after application to the upper side of the leaves. It caused "burning" on the leaves and seemed to render the pods more susceptible to fungus attack.

SUMMARY AND CONCLUSIONS

The results obtained show clearly that oil will not control almivora on cacao as it controls Cercospora on banana. ugh it does not itself influence the pathogen, it retards the opment of lesions by delaying infection and augments the tiveness of copper fungicides. However, it is too early to mend the use of oil for practical control purposes. Further tigations are needed, especially under field conditions. The ntage of oil in the spray should not exceed 50% because of hytotoxic effects, and its application might be safer in d plantations.

The use of pods for the evaluation of fungicides seems to a new and promising field. Using this rapid method, the ive effectiveness of the fungicides used could be established.

RESUMEN Y CONCLUSIONES

Los resultados obtenidos muestran claramente que el aceite ntrolará P. palmivora en cacao como lo hace con Cercospora nano. Aunque no afecta al patógeno, retarda el desarrollo s lesiones demorando la infección y aumenta la efectividad s fungicidas de cobre. Sin embargo, es muy temprano recomen- l uso de aceite para propósitos prácticos de control. Se lta más investigación, especialmente en condiciones de campo. rcentaje de aceite en la aspersión no debe exceder al 50% a su efecto fitotóxico y la aplicación puede ser menos rosa en plantaciones con sombra.

El uso de mazorcas para la evaluación de fungicidas parece r un nuevo campo promisorio. Usando este método rápido, ría determinar la efectividad relativa de los fungicidas .

SUMMARY OF DISCUSSION

Mr. L. Goberdhan (Trinidad)

Very good control has been obtained by the use of oil for Leaf Spot (Cercospora) of banana. It was decided to try this o for any possible effect on the control of Pod Rot (Phytophthora palmivora) of cacao. A low volume knapsack type sprayer was utilised, the spray being applied every three weeks during the season. After three years of trial no control of Phytophthora obtained; there was no phytotoxic effect on the cacao.

CERATOSTOMELLA WILT IN CACAO IN TRINIDAD

E.F. Iton[M]

In March, 1958, a wilt disease of cacao, new to Trinidad and
ed by Ceratostomella fimbriata (Ell. & Hals.) Elliot, broke
in widely separated cacao-growing areas of the Northern and
ral Ranges; the disease had spread throughout the island by
end of 1958. At River Estate, situated in the Northern Range
Diego Martin, 2153 deaths of cacao trees, ascribable to Cera-
omella attack, have been recorded up to February, 1960, out of
ee population of approximately 90,000 - nearly a 2½% loss in
years.

The symptons in Trinidad are generally similar to those des-
ed for the disease in Costa Rica, Colombia, Ecuador and Vene-
a, and have already been described by the author (Iton, 1959).
pathogen has been isolated and inoculation tests have success-
y been performed.

As in some of the other countries from which this wilt dis-
has been reported, Scolytid beetles have invariably been
d in association with the diseased condition. These small
:ts bore into the wood of the cacao trees and extrude copi-
quantities of wood dust from their excavations.

ase transmission

The epidemiology of the disease has been discussed by the au-
(Iton, 1959). He concludes, from studies of the spatial dis-
ition and the chronological sequence of disease incidence at
Estate, that wind is one of the agents involved in the trans-
on of the disease. This hypothesis has received support from
xperimental finding that particles of wood dust, containing
numbers of chlamydospores of C. fimbriata, can easily be col-
d on greased slides suspended near infected cacao trees.
spores have been observed to germinate in several media. The
dust is physically identical with that extruded from the tun-
made by the boring insects and evidently comes from trees af-
d by Ceratostomella wilt; such infected trees always contain
high concentrations of chlamydospores, particularly in the
loured tissues surrounding the tunnels of the borers and in
ascular rays.

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onal Research Centre, Imperial College of Tropical Agriculture,
idad.

The pathogen produces also a profusion of thin-walled endoc nidia on surfaces of diseased trees artificially exposed by woun or lesions and in the tunnels of the Scolytid beetles. These en conidia could conceivably become air-borne and they are known to germinate with great ease both in free water and in a humid atmo phere without free water.

Perithecia are also produced in large numbers on artificial exposed tree surfaces and on natural surfaces provided the humid ty is high. From the ostioles of these perithecia ooze masses o mucilage in which the ascopores are embedded, and it is believed that mites may sometimes be effective agents in localized dissem nation of ascospores when they dislodge the mucilagenous masses which adhere to their bodies. This suggestion is based on the o servation that mucilagenous exudations from the perithecia of an ther Ceratostomella species often collect on the bodies of mites which are frequently present on cacao trees in large numbers. This other species is widespread at River Estate and it bears ab dant perithecia on the diseased pods of otherwise healthy trees. It is conceivable that Scolytid beetles also could be vectors of ascopores by this method.

There is, however, another and apparently more common metho which Xyleborus beetles could transmit the wilt disease in Trini

Divergent accounts of the role of Scolytid beetles in the spread of Ceratostomella fimbriata appear in the literature. I Venezuela, Malaguti (1958) was unable to procure insect transmi sion of the disease and also failed to find the causal fungus e ther on or in the insect body. In Colombia, on the other hand, Naundorf, Idrobo and Sanclemente (1956) were able to obtain ins transmission. These authors have given detailed postulates of modifications of insect transmission without, however, offering perimental evidence in support of these postulates.

Breeze, from wilted cacao trees in Trinidad, collected sev species of Xyleborus amongst which the British Museum has ident fied:

1. Xyleborus confusus Eichh.
2. X. hirtella Schedl
3. X. ferrugineus F.
4. X. corniculatulus Schedl
5. X. posticus Eichh.
6. X. sp. nov.

To determine the role of these beetles in the transmission of ratostomella wilt, the alimentary canals of many specimens of h species were removed by microdissection and examined. Chlamy-spores of C. fimbriata have been found in the rectum of most of e species of beetles; the presence of these thick-walled spores the rectal region of the alimentary canal implies their ability resist active digestion and satisfies one necessary criterion classifying the beetles as potential vectors. The viability of e chlamydospores, after passage through the alimentary tract of e beetles, was demonstrated by the simple experiment of placing e insects in sterile conditions, allowing them to defecate and llecting and incubating the faeces. Some five per cent of the ores present in the faeces germinated.

The author has observed Xyleborus beetles, in the laboratory, cover a distance of 20 m in one flight. Their habits in the ld are not known in any detail, but assuming that the insects migratory (if only occasionally), it seems reasonable to as-ne that the excretion of viable chlamydospores in their faeces es the beetles vectors of Ceratostomella wilt disease in cacao.

trol

In the light of the evidence adduced that boring insects could as direct vectors of Ceratostomella wilt and as indirect vec-s by the production of wind-borne infected wood dust, it would n that disease control could be effected by control of the in-ts; but the practicability of controlling the insects cannot be ssed until knowledge of their habits has been obtained.

Diseased trees should not be cut into pieces and left in the ld, for exposure of wood surfaces induces prolific sporulation. lification of the entire tree, followed by the burning of all ts, should be practised; and if the removal of diseased trees their incineration is carried out soon after the trees show symptoms, very numerous wood-boring insects (which apparently ate early from diseased trees as the wood dries out) will be royed.

Wounding of trees should always be avoided as far as possible, although existing lesions are not essential to the penetration he bark by boring beetles, the incidence of borings is higher ounds than on intact surfaces. Where pruning of cacao trees is tised, the freshly exposed surfaces should be treated to repel cts.

SUMMARY

Experimental evidence suggests that wood-boring Scolytid bee tles are responsible for the spread of a wilt disease, new to cac in Trinidad, caused by Ceratostomella fimbriata. The insects ex- trude copious quantities of wood dust from their tunnels, and ex- periments have demonstrated the presence of viable chlamydospores of C. fimbriata in particles of wood dust collected on greased gl slides suspended near infected cacao trees. The presence of simil chlamydospores has been demonstrated in the rectum of several Xyl borus species, and the spores have been shown capable of germinat when voided in the insect's faeces.

RESUMEN

Hechos experimentales sugieren que gorgojos taladradores de madera del grupo Scolitidae son los causantes de la diseminación de la enfermedad de marchitamiento, nueva en el cacao de Trinidad causada por Ceratostomella fimbriata. Los insectos sacan grandes cantidades de polvo de madera de sus túneles y mediante experi- mentos se ha demostrado la presencia de clamidosporas de C. fim- briata en partículas de polvo de madera colectada en placas con grasa suspendidas cerca de árboles de cacao infectados. Se ha de- mostrado también la presencia de clamidospóras similares en el recto de algunas especies de Xyleborus, y las esporas han germina do cuando extraidas de las heces del insecto.

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SUMMARY OF DISCUSSION

Hansen (IAIAS)

Is the fungus left in the roots after the tree had been killed
l does the recommendation concerning the destruction of the tree
fire include the roots?

Cope (ICTA)

There is no evidence that the roots contain the fungus; the
:ommendation for destruction of the tree includes all the parts
ıt are practical to remove.

Kjellander (Ecuador)

At Clementina we are losing several thousand trees a year from
atostomella especially ICS 1 and ICS 45. We have tried control by
mical sprays both from the ground and using a helicopter but have
ıieved no conclusive results.

ofessor C. Navarrete-Sanchez (Venezuela)

Work in my country has not clearly shown that insects were
sponsible for transmission of Ceratostomella. In fact evidence
far was in favour of entrance by wounds caused by machetes,
l other causes. We have had outbreaks of Ceratostomella without
sects and have found insects when there was no Ceratostomella.
is difficult to apply conclusions found in one country to the
oblems of another, nevertheless, the evidence produced by Mr.
on on the transmission of the disease by insects in Trinidad is
knowledge which would be of benefit in solving the problem of
ıs disease.

L. Goberdhan (Trinidad)

A recent check survey of this problem in Trinidad has shown no
gnificant spread. There is some evidence to suggest that a
tial control may be effected by the use of "Toxaphene" in
ıtrolling the insects.

M.H. Breese (ICTA)

Little, if anything is known about the Xyleborus beetles that
possibly implicated in the spread of Ceratostomella disease in
nidad. Of the six species that have been collected from infected
es, five were new to the British Museum and one is new to science.
species (X. confusus Eich.) is on the other hand very common in

Trinidad and frequently comes to light especially in the rainy season.

It was true to say, however, that by and large, bark beetles of this type rarely attack healthy wood, nor do they remain in dea wood that is beginning to dry out. In Trinidad, the highest populations have so far been found in trees that have been reporte dead about a week. An interesting parallel might be drawn betwee the Ceratostomella-Xyleborus complex and the relationship between the Dutch elm disease (Ceratostomella ulmi) - bark beetle association in the United States. Diseased trees are probably attractive to Xyleborus beetles and they in their turn by their borings create a source of inoculum that could possibly be windbo Iton had shown that Xyleborus beetles could act as vectors but th true role in the spread of the disease in Trinidad, is, as yet, un- known.

Dr. V.C. Quesnel (Trinidad)

I have reason to believe that the "blast" of 1727, to which Mr. Moll refers in his brochure "Cacao in Trinidad", was not a hurricane but a fungus disease, the most likely one being Ceratostomella disease. In the many historical works which I consulted last year I found references to fourteen such blasts affecting Trinidad, Grenada, Martinique, Dominica, Santo Domingo, Haiti, Jamaica and Cuba and ranging in time from 1664 to 1892 wit clusters in the years 1664 - 1671 and 1715 - 1727. There were n references to blasts in the Central American and South American countries and I would be pleased to hear from the delegates from these countries whether they know of any records of widespread destruction of cacao during the seventeenth and eighteenth centur

Chairman (L.L. de Verteuil)

Before closing this Session, I should like to make some obse vations. In the first place I would like to place on record tha it was through the efforts of Mr. J. Spence, Plant Pathologist a Mr. G. Stell, Entomologist of the Ministry of Agriculture that t outbreak of Ceratostomella in Trinidad 1958 was identified. The first culture of the fungus from infected material was obtained b Miss B. Morris, Curator of the Culture Collection at the Colonia Microbiological Institute, which confirmed the diagnosis referre to above.

Inoculation tests have been carried out on various clones b Mr. Goberdhan which has shown that there is a wide range of sus- ceptibility to the disease. Criollo types show the highest sus- ceptibility and the Forasteros the highest tolerance.

Viewing the problem on a regional basis, there is evidence to
gest that the recent outbreaks of this disease are associated
h abnormally dry conditions prevailing in the cocoa-growing
ntries of this hemisphere over the past three years, and that
disease did not occur in normally healthy locales. However,
e it gained a foothold, no doubt it would be very difficult to
dicate. The disease exploited unthrifty conditions, such as a
k of shade and poor drainage.

A REVIEW OF THE PROBLEMS OF SHOT HOLE BORER (COLEOPTERA, SCOLYTIDAE AND PLATYPODIDAE) ATTACK IN COCOA IN WEST AFRICA

P. F. Entwistle[x]

INTRODUCTION

There has been much confusion in West Africa about the prec status of many of the species of Scolytidae and Platypodidae ass ciated with cocoa. Members of these families of beetles usually tack only dead or dying wood and so are major pests of felled ti Very few have been recorded as primary pests of healthy plants.

Many examples can be given where the role of Shot Hole Bore in the death of cocoa trees has been mistaken. In 1958, Xyleboru urichi Samps. and Doliopygus conradti Strohm. were suspected of causing the death of mature Amazon cocoa trees at Dunkwa in Ashs Later investigations revealed that although attack was heavy th adult insects had not penetrated deeply into the wood, breeding had not occurred and fungi usually associated with Shot Hole Bo attack were absent. An infection of the roots showed that an ex sive area of rotted wood occurred where the tap root had met an structing rock.

Hypothenemus pusillus Egg., which is a bark beetle and not true ambrosia beetle, has often been incriminated as a pest of mature and seedling cocoa. At Tafo in Ghana, several seedlings apparently as a result of attack by this species, but examinati of the tap roots again revealed severe distortion and associate necrosis.

Heavy infestations of Xyleborus semigranosus Blndf. and X. mascarensis Eichh., were observed at Tafo in 1957, in previousl thrifty Amelonado trees which had died. That Shot Hole Borer wa not the cause of death was clearly indicated by the fact that n all trees which died were attacked (Entwistle, 1959).

The Shot Hole Borers which have been recorded attacking co in West Africa are given in Table 1. Many of the species are po phagous and some widely distributed in the tropics. The distrib given is for one host plant (Theobroma cacao) only and is not n sarily the complete geographical range of each species.

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[x] West African Cocoa Research Institute, Ibadan, Nigeria

able 1. Scolytidae and Platypodidae recorded on cocoa in West Africa

	Countries in which recorded:
colytidae	
oecilips confusus Egg.	N.
. sierraleonensis Egg.	I.
ypothenemus ater Egg.	G. N.
. mozambiquensis Egg.	S.
. mulongensis Egg.	I.
. pusillus Egg.	S. I. G. N.
tephanoderes aulmanni Hag.	G.
. polyphagus (Egg.)	I. C.
. solitarius Schedl	I. N.
. theobromae Egg.	C
ylotentus ater Egg.	N.
. concolor Hag.	I.
ileborus barumbuensis Egg.	C.
. camerunus Hag.	I. G. C. (and Uganda)
. collarti Egg.	G.
. ficus Egg.	I.
. morstatti Hag.	All W.A. cocoa areas
. mascarensis Eichh.	G.
. nitidipennis Murray	G.
. perforans Woll.	G. C. St.
. semigranosus Blndf.	I. G.
. semiopacus Eichh.	C.
. subsulcatus Egg.)	
urichi Samps. (= crenatus Egg.)	G. C.
xylocranella Schedl	G

Platypodidae

Doliopygus conradti Strohm.	G.
(= v-grandis Samps.)	
D. gracilior Schedl	G.
Platypus mordax (Samps.)	G.
(= Stenoplatypus)	

(S. = Sierra Leone I. = Ivory Coast G. = Ghana
N. = Nigeria C. = Belgian Congo St. = San Tho

Primary scolytid pests of cocoa

The majority of species listed are secondary pests, attacking only moribund cocoa. Only three are known to cause primary damage.

Poecilips confusus Egg. was recorded by Gregory (1954) attacking healthy cocoa seedlings in Nigeria, but appears to be rare and little is known about it.

Hypothenemus ater Egg. has been noted as a primary pest only in Niger and Kabba Provinces of Nigeria on the northern fringe of cocoa cultivation. Trees up to the second and third years may be attacked throughout the year, though in the wet season the galleries are usually abortive. During the dry season, when attack is at its peak it is reported as being a primary cause of die-back of terminal shoots. The galleries are of the type also noted for H. pusillus, where after penetration, the tunnel turns at right angles and attack is concentrated immediately below the bark. (A'Brook, unpublished observations).

In Ghana, where H. ater has also been noted in cocoa, attack has been observed only on previously damaged wood, e.g., broken branch tips.

In Sierra Leone Hypothenemus mozambiquensis Egg. was recovered from a batch of seedlings the majority of which had been attacked by Xyleborus morstatti Hag., but as it was not present in the same plants as the last species it may be primary pest in its own right (Entwistle, in press).

Xyleborus morstatti Hag. is the principal shot hole borer and affects cocoa throughout West Africa. Plants up to three years d may be attacked but seedlings in their first year are particu-rly susceptible.

stribution and host plant range of Xyleborus morstatti

X. morstatti was first described by Hagedorn in 1912, from East rica, the type locality being Amani in Coffea bukowensis. Since t time it has spread with coffee cultivation throughout West, st and Central Africa and the Far East. There is a single doubt- record from Grenada in the West Indies in dead cocoa (Anon., 17).

In West Africa X. morstatti has been recorded from Turreanthus ricana Peleger (Schedl, 1954a), Albizzia zygia Macbride (Schedl, 54b), Bauhinia tomentosa L. and mango (in Brown, 1955) in addition coffee and cocoa. In East Africa Brown also mentions Melia darach L. and Erythrina species.

Outside West Africa it has been found attacking coffee in lagascar (Frappa, 1933), avocado pear (Persea americana Mill.) in ritius and the Seychelles (Jepson, 1939 and Brown, 1955), coffee, talaria sp. and Clerodendron sp. in Mysore (Subramanium, 1935 and n., 1941). Schedl (1959) records it from Ceylon, but gives no t plants. In Java and Sumatra it has been found in coffee (Berge- n, 1927 and others), mahogany (Surieteria mahogoni and S. rophyla)(Kalshoven 1926), cocoa (Van Hall, 1926), Elaeis guineensis gers, 1922) Erythroxylum cocoa Lam., Dendrobium veratrifolium and bucus canadensis (in Brown, 1955). Du Pasquier (1932) found it in fee in Indo China. In Fiji it has been found in avocado pear ver, 1933 and others).

Some species of coffea are readily attacked whilst others show tle or no susceptibility. Chevalier (1931), reporting the find- s of Sundres in Liberia, said that X. morstatti prefers wild coffee robusta) but that C. arabica is also susceptible; neither C. nophylla nor C. Liberica were found to be infested.

Richie (1935), also noted X. morstatti in C. arabica in imanjaro and on C. robusta elsewhere in Tanganyika. Mallamaire 54) wrote that amongst those attacked were C. arabica and C. ephora and that other species (C. Liberica and C. excelsa) e often less susceptible. Rio Nunez coffee (C. stenophylla), often cultivated, was seldom attacked and appeared immune.

The factors governing the relative susceptibility of Coffea cies have not been investigated.

Gallery Construction and Life Cycle of X. morstatti

The biology of X. morstatti has usually been studied on coffe its principal host. Attack is confined to seedlings and to main branches up to two years old. (Mallamaire, 1954).

The whole of the adult and immature life is passed within th wood, except for copulation and the search for a suitable host pl

The gallery is formed by a single female unaccompanied by a and has a characteristic pattern. Entering radially the gallery turns either to left or right and almost encircles the pith. In transverse section the gallery appears sickle-shaped. Arising ap ximately from the centre of the curved portion a brood chamber, h to one centimetre long, extends upwards into the pith. In some cases it may also go downwards.

In coffee each adult lays from 30 to 50 eggs (Mallamaire, 19 Brown (1955) noted from two to seven only in avocado pear, whilst Lever recorded up to 26 for the same host plant. The eggs are la compared with the adult and the oviposition period is extended so that eggs, larvae and pupae may be present at one time in the sam brood chamber.

Lavabre (1958) (Table II), summarised life cycle data.

Table II. The life cycle of X. morstatti on Coffea robusta in the French Cameroons.

	Maximum (days)	Minimum (days)	Average (days)
Preparation of galleries	10	7	8
Oviposition and incubation	6	4	4
Larval stages	18	9	11
Pupal stage	9	5	7
Pupal ecdysis	2	1	2
Sexual maturation of adult female	6	5	6
Totals =	51	31	38

His figures agree well with the observations of Ultée (1931), on coffee in Java, who quoted a pupal stage of six to seven days, pu pae and some adults present after 30 days and many adults present within 42 days.

Gregory (1954), gave the only data available for cocoa. He erved that a batch of 20 eggs was laid in the first two or three s, after which the rate of oviposition fell rapidly. The number young produced by a single female varied considerably. For 14 leries the number of progeny ranged from 5 to 54 with a mean of 4. The average ratio of male to female beetles was 1:4.6, but individual galleries ranged between 1:1.5 and 1:9.0. The res- tive durations of egg, larval and pupal stages were 5, 6 and 7 s.

ptoms of Attack and Nutrition of X. morstatti

In addition to the extremely small entrance hole, attacks on dling cocoa are generally accompanied by a flow of mucilage from gallery. This is dark at first but dries as a white streak on bark. At a later stage a distinctly darker sunken area often elops around the point of entry and in some cases the stem may n swell slightly in the same region (Plate I). Severe attack cul- ates in extensive wilting and die-back, often leading to complete th of the plant.

No such sap exudate has been observed in coffee, but when green ms are attacked the dark sunken area is more distinctive than in oa.

On avocado pear Brown (1955), mentioned a soft white powdery erial around the entrance of the gallery. He regarded this as a nd reaction of the host plant.

The exact nature of the adults' food is not known, but it is erally believed that the larvae feed upon the ambrosia fungi which elop on the walls of the brood chamber and the gallery. Mallamaire 54), suspected that they also ate the pith in coffee.

Ambrosia fungi belong to the Moniliales but it is thought that area of necrosis which develops in the wood around the gallery due to fungi other than the ambrosia fungus. (Plate II). In na, Botryodiplodia theobromae Pat. and Calonectria rigidiuscula rk. and Br.) Sacc. (the perfect stage of Fusarium decemcellulare ck), both of which are wound parasites of weak pathogenicity, e been isolated from 'lesions' caused by the beetle (Anon, 1951). Nigeria Gregory (1954) isolated B. theobromae twice from galleries X. morstatti and once from those of Stephanoderes solitarius edl. Spores did not appear to be carried on the surface of the tles, for in 13 cases in which adults were allowed to walk on ture media no Botryodiplodia developed.

Also in Nigeria Donald (1959) recorded B. theobromae and C. idiuscula from discoloured wood around galleries in living

portions of attacked stems. Kay (unpublished data) made inoculat from the interface of healthy and infected wood about galleries o shot hole borers and in six cases out of 24 isolated C. rigidiusc The remaining 18 gave other undetermined fungi.

Twigs of avocado pear yielded Cladosporium cladosporiodes (Fresen) de Vries and Penicillium pallidum G. Smith (Brown, 1955)

Cachan (1957), during observations on Platyscapulus auricomu Schauf., in felled logs of Macrolabium, recorded that many fungi were present in the galleries in addition to the ambrosia fungus. activities of the larvae tended to suppress development of all bu the ambrosia fungus and consequently, as the breeding activities a gallery developed, the proportion of ambrosia to other fungi in creased. Conditions in the galleries were frequently unsuitable the germination of other fungi, which were generally present only spores. The mycelium of the ambrosia fungus was digested by the larvae but the spores passed through the gut unharmed.

Conditions governing attack by X. morstatti

In the wet season, attacks on cocoa are uncommon and infesta tion does not become serious until the beginning of the dry seaso after which there is a continuous build up until wet conditions i tervene.

There seems also to be a broad association in West Africa be tween climate and the intensity of X. morstatti attack on cocoa. Sierra Leone where, despite a high annual rainfall, there is an intense dry season with a strong dessicating harmattan wind, shot hole borer is a serious pest. In Ghana, where conditions are mor equable morstatti is seldom encountered as a pest. At Oyoko the peak infestation occurred in January and reached only 3.1 per cen of plants attacked (Anon, 1951).

In the Ivory Coast Alibert (1951), mentioned 25 per cent of seedlings attacked at Bingerville, though this is a coastal stati and may have been subject to the dessicating effects of stronger winds than would normally be encountered in most of the cocoa gro ing area.

In Nigeria the dry season is very pronounced and may last fr three to four months. Incidence of attack is often high. In an experiment at Ibadan shot hole borer was first noted in November. By the beginning of December 15.4 per cent of seedlings had been tacked and this increased to 34.8 per cent by the end of the mont At the end of the following March 84.5 per cent of plants had bee attacked, 52 per cent were dead and a further 28 per cent severel wilted. (Anon, 1959).

Conditions are extremely humid in the French Cameroons and ot hole borer attack on cocoa is rare, though robusta coffee suf- rs considerably (Lavabre, private communication, 1960).

The general geographical pattern of attack is related to broad imatic trends and a connection exists between the progress of tack and local climatic, edaphic and shade conditions. The actual use of attack is in doubt: at Akure in Nigeria, Donald conducted experiment in which half of the seedlings were watered throughout e dry season, whilst the other half were left without any form of rigation. By the end of the dry weather 70 per cent of the un- tered plants had wilted and showed die-back, whilst the watered es were still healthy. However, the incidence of borers was the me on both watered and unwatered plots (Anon, 1959). This suggests at attack in cocoa may be partly the effect of dry season condi- ons on unknown wet season host or hosts. It is of interest to e that in Mysore X. morstatti was found to breed in Crotalaria Clerodendron species during the four or five summer months when was not present in coffee (Anon, 1941).

The physiological state of cocoa seedlings during the dry son evidently influences the degree to which attack progresses. incidence of attack in plants grown under shade may be high but development of galleries is generally poor, most of them being rtive. Where conditions are more rigorous breeding occurs more en.

The entrance hole of an abortive gallery is finally closed by a liferation of callus tissue and eventually is very difficult to ect. Whilst the adverse effects of abortive galleries are less n those which develop normally, they inevitably result in some gal infection of the wood. The extent to which this affects a nt may depend upon its subsequent dry season history.

When breeding proceeds to completion the effects of one gal- y are sufficient to cause die-back to the point of attack. As ry is often low down on the stem this may mean complete death of plant.

Betram (1931), studied the effects of climate on the biology of morstatti on coffee in Batavia. He concluded that temperature reased the rate of development and rain promoted the growth of rosia fungus. Infestation was therefore slight whilst there was ow water content in the twigs, as in the dry season, though at s time injury was more noticeable as the twigs withered. This a result of sealing off of the tissues, by gum or tyloses, as a tective measure of the plant against the fungi.

In West Africa X. morstatti is not known to be subject to th attacks of either parasites or predators whilst in its galleries: Ultée (1931), reported that when X. morstatti first appeared on coffee in Java it was readily parasitised by a species of Tetrastichus (Hymenoptera, Eulophidae) that normally attacked Xyleborus morigerus Blndf., also a pest of coffee. When morigerr began to decrease in numbers parasitism of X. morstatti also de- creased and when morstatti was present almost exclusively it was not normally found to be parasitised. Later, a parasite of X. morstatti appeared which was indistinguishable from the one alre mentioned, but which did not attack X. morigerus.

Experiments in the insecticidal control of X. morstatti

Gregory (1954), found that attempts at control by hand appl cations of insecticides gave little information of value and Don (Anon, 1958 and 1959) showed that treatment with a urea-formalde lacquer (containing 10 per cent dieldrin and 4 per cent aldrin) with 0.5 per cent dieldrin emulsions gave no measurable control.

By painting twelve inch lengths of twig with insecticides a tying them to cocoa trees Gregory (1954), obtained the results s marised in Table III.

Table III. Shot hole borer infestation of cut twigs ten days after treatment with insecticides

Insecticide	Concen- tration	% twigs not damaged	Colonies per 100 twigs	Dead beetles & empty galleries	Live breed colon
DDT emulsion A	2.5	70	37	8	3
Aldrin emulsion	1.0	65	48	10	19
Dieldrin emulsion	1.0	83	17	9	1
Endrin emulsion	1.0	88	12	3	4
DDT emulsion B	2.5	83	17	4	1
Control	-	12	158	21	74

Endrin was the most effective in preventing scolytid entry dieldrin in preventing breeding, but it must be mentioned that t species concerned would all be of secondary pest status.

Working with coffee in the French Cameroons Lavabre (1959) com-
ed dieldrin (0.4 per cent), endrin (0.185 per cent) and gamma-BHC
18 per cent) in an experiment in the control of X. morstatti.
ldrin gave the best control (93.9 per cent after two applications)
endrin was also promising (78.1 per cent after one treatment).

effect of several cultural conditions
populations of X. morstatti

In June 1959, an area of seedlings was planted under palm frond
de near Ibadan, Nigeria, and a comparison of the effects of the
lowing treatments on growth of virus and non-virus infected plants
made:-

A. Vigorous grass ground cover

B. Natural regeneration of weeds

C. Mulch (straw)

D. Bare soil

In addition to these the plots were split, fertilizer (NPK)
ng applied to half of each. The experiment consisted of five
cks, each of four plots, three of the blocks being Amelonado and
other two Amazon cocoa.

By December, 1959, the area was heavily infested with shot hole
er, records of the incidence of galleries of which were taken in
first three months of 1960 before virus had been introduced into
plants. Statistical analysis of these data indicated that signi-
antly less plants were attacked ($p = .005$) in the mulched and bare
l plots (C and D) than in the plots with a growing ground cover
and B). (Table IV) (Entwistle, unpublished data).

Table IV. Percentages of seedlings attacked by X. morstatti under different cultural conditions

Treatments	January	February	March
A + B with fertilizer	49.25	58.50	65.75
A + B without fertilizer	45.50	56.75	61.75
C + D with fertilizer	34.75	48.50	51.50
C + D without fertilizer	25.75	36.50	44.50

(see page 10 paragraph 3 for explanation of treatments).

Analysis of growth data showed seedlings in treatments C and to be most vigorous, an effect that seems to have been enhanced b fertilizer.

There was no detectable difference in susceptibility between Amazon and Amelonado plants but, probably due to the seedlings having been grown under shade, very few plants died from borer attack, most of the galleries being abortive. A more critical test must include comparisons of survival rates of different type of cocoa under more rigorous conditions, before conclusions concerning relative susceptibilities can be drawn.

Discussion and Conclusions

Whilst many species of shot hole borer will attack moribund cocoa, only three are definitely known to be primary pests of hea thy plants, and only one of these is of widespread importance in West Africa.

Much confusion has arisen in the past between primary and se condary attack. The picture has tended to be most misleading in areas where an intense dry season leads naturally to considerable die-back, and the production of dessicated tissues suitable for attack by species of secondary importance.

As far as is known there have been no instances of primary attack to mature cocoa. Normally attack is to plants in their first year in the field and when it does extend beyond this, except in the more marginal cocoa growing areas, tends to be of neg gible importance.

Intensity of attack varies throughout West Africa and is gov ned by broad climatic trends, principally the duration and severi of the dry season. More local conditions have a profound effect upon the degree to which galleries develop and on the reactions o

plants to attack. In Nigeria, where attack by X. morstatti intense, the cultural conditions under which seedlings are grown of prime importance to survival. The ecological factors involhave yet to be assessed, but those which affect the water reions of the seedling, such as shade, soil conditions and competion with other plants, will probably prove most important.

The reasons for X. morstatti attack in cocoa are not yet fully erstood. Attack may be to some extent due to the effect of dry son conditions upon an unknown wet season host plant, rather n merely the dry season rendering cocoa suitable for attack. It interesting to note the seasonal alternation between coffee and d host plants in Mysore.

The development of the beetle is dependent on the growth of rosia fungi in the gallery, where the larval and most of the lt life are passed. It is believed that fungi other than the rosia fungus cause the necrosis of the wood that develops und galleries. Calonectria rigidiuscula and Botryodiplodia obromae are both concerned and are wound parasites of weak pagenicity.

The failure of normal insecticidal techniques to effect any ree of control in cocoa is perhaps due to the beetle penetrag the stem rapidly and not being in contact with the treated face sufficiently long to accumulate a lethal dose. Should a tle succumb after entry, the act of penetration itself, and the gal attack following, may be sufficient to cause the death of its living under the seasonal stress of drought.

Failing the development of an insecticidal technique that rents entry of the beetle, future research should be concened on the manipulation of cultural conditions so that the it may be able to withstand attack.

SUMMARY

There has been much confusion in the past as to the status Shot Hole Borers as pests of cacao in West Africa. Many examples could be given of instances where healthy tissues were apparentl attacked, but fuller investigations have shown the plant was al- ready unhealthy prior to attack. Only three Shot Hole Borers can at present be regarded as primary pests. Two of these can be dis missed as of relatively little importance. The principal primary Shot Hole Borer is Xyleborus morstatti Hag., a true ambrosia bee Recorded first on Coffea bukowensis in Tanganyika in 1912, this species has become very widespread throughout the whole of West, Central and East Africa and much of Asia. There is only one doub ful record, from Grenada, in the New World. It is now a major pe of coffee and has been recorded upon a wide variety of other pla

The whole of the adult life of X. morstatti is spent within the wood, except for copulation and the search for a fresh host plant, where larvae, probably also adults, feed upon ambrosia fungi growing upon the walls of the gallery. Typically, X. mor- statti is a dry season pest of seedlings, these being most sus- ceptible during their first year of growth, after which the de- gree of attack tends to decrease and to have little adverse ef- fect. In the more marginal cacao growing areas it may exception ally extend up to the third year. Under severe dry season condi tions attack may lead to wilting, die-back and eventually to dea

A strong association appears to exist between climate and intensity of attack to cacao in West Africa. Where the dry seas is long, as in Sierra Leone and Nigeria, the percentage of plan attacked is high, but where rainfall is more evenly distributed throughout the year as in Ghana and the Cameroons, X. morstatti is not normally a significant pest. Local conditions have a con siderable effect upon the progress of attack and upon the react of the seedling to attack.

RESUMEN

En el pasado ha habido mucha confusión sobre la situación los gorgojos taladradores del tallo (Shot Hole Borers) como pes del cacao en Africa occidental. Se pueden citar muchos ejemplos que tejidos sanos estaban aparentemente afectados, pero investi ciones más completas han mostrado que la planta estaba ya enfe antes del ataque. Solamente tres tipos de gorgojos taladradores tallo se consideran a la presente como pestes primarias. Dos d ellos no merecen mucha atención por tener muy poca importancia

cipal de estos gorgojos es Xyleborus morstatti Hag. Registrada
era en Tanganica en 1912, esta especie se ha diseminado amplia-
e en todas las regiones occidentales, centrales y orientales de
ca y en una gran parte de Asia. Hay solamente un informe dudoso
renada en el Nuevo Mundo. Es actualmente una peste principal en
y ocurre en un gran número de otras plantas.

El total de la vida adulta de X. morstatti la pasa dentro de
adera, excepto para la época de copulación y cuando busca una
a planta, en donde las larvas, y probablemente también los a-
os, se alimentan de hongos del grupo ambrosia que crecen en las
des de las galerías. X. morstatti es típicamente una peste de é-
s secas en plántulas jóvenes, siendo éstas más susceptibles en
rimer año de crecimiento, después del cual el grado de ataque
de a disminuir y a tener efectos menos perjudiciales. En las
s más marginales de cacao, el ataque puede extenderse excepcional-
e hasta el tercer año.

Bajo condiciones severas de sequía, un ataque puede producir mar-
amiento, muerte regresiva, y eventualmente la muerte total del ár-

Parece que existe una estrecha correlación entre las condiciones
áticas y la intensidad del ataque en Africa occidental. En regiones
la Sierra Leone y Nigeria, que tienen un largo período de sequía,
orcentaje de las plantas atacadas es alto, pero en aquellas areas
e la precipitación pluvial está distribuida de una manera más pa-
a través del año, como es el caso en Ghana y en la República de
rón, la X. morstatti en general no constituye una peste de gran im-
ancia. Las condiciones locales tienen un efecto marcado sobre el
reso de la enfermedad y la reacción de las plantas de semillas al
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THE INTERACTION BETWEEN SWOLLEN SHOOT DISEASE AND MIRIDS ON COCOA IN NIGERIA

D. Kay, J.F. Longworth & J.M. Thresh[*]

INTRODUCTION

Cocoa in Nigeria is heavily attacked by Mirids (capsids), principally Sahlbergella singularis Hagl., which damage the young shoots when feeding by injecting a toxic saliva. The resulting necrotic patches are commonly invaded by Calonectria rigidiuscula (Berk & Br.) Sacc., and this fungus may affect the canopy to such an extent that the trees sometimes die. Crowdy (1947) showed that Mirid feeding damage alone killed only green tissue, but when the lesions became infected with C. rigidiuscula woody tissue could also be killed.

The swollen shoot condition of cocoa was shown to be caused by virus in 1939 by Posnette (1940) in Ghana. Previously this disease was considered to be of minor importance in the general problem of cocoa die-back caused by Mirids and by adverse environmental conditions (Voelcker & West, 1940). Until recently, effective control of Mirids has not been possible and they are so ubiquitous as to occur frequently in farms also affected by the viruses causing swollen shoot disease. As a result, the effects of virus have been confounded with Mirid damage and the associated die-back fungus.

Observations in Ghana (Williams, 1953) and in Nigeria indicated that a virus infection predisposed trees to subsequent attack by Mirids. In fact wherever the growth of the cocoa is weak, or the canopy is broken there is a tendency for "capsid pockets" to form (Williams 1953, Hoblyn, 1956). In such areas where the canopy has been reduced increased exposure leads to adverse changes in the microclimate within the crop, and to invasion by a ground vegetation of grasses and herbaceous weeds. Under these conditions farms which are attacked by both Mirids and virus may become unproductive within a few years. This decline can be accelerated by the peasant farmers who often interplant with food crops.

Investigations into this complex interaction were greatly assisted by the application of the chemical control measures introduced against Mirids in 1956. Naturally infected cocoa farms, sprayed with B.H.C. showed spectacular improvements (Thresh, 1960), and these results prompted the suggestion that these insects largely determine

[*] West African Cocoa Research Institute, Nigerian Substation, Moor Plantation, Ibadan, Nigeria.

fect of swollen shoot disease on cocoa in Nigeria. Further aspects the situation were examined in formal statistical field trials. e present paper discusses the results of these trials which were tended to examine this important interaction.

EXPERIMENTAL WORK

The interaction of Mirids and Virus

a) Koroboto observation plot

The spread of swollen shoot disease has been observed in peasant cocoa at Koroboto since 1953, and since that date the number of infected trees has risen from 49 to 606 in August 1959; almost 85% of the trees in the farm are now infected, and the effects of the complex of viruses at Koroboto are typical of others in the Area of Mass Infection. Individual tree yield records have been taken since 1954. B.H.C. spraying started in March 1956 to control Mirids.

The effect of virus on yield is difficult to estimate because the condition of the trees is only partly caused by the length of time they have been infected with virus. Nevertheless there were significant negative correlations between the number of months the tree had been showing symptoms and the yield in pods per tree per year for the crop seasons 1954 - 55 and 1955 - 56. Yields in each season were also correlated with girth, and partial correlations between yield duration of infection were obtained using this relationship.

le 1 Correlations between Yield, Girth and Duration of infection at Koroboto Swollen Shoot Observation Plot

Crop Season	Yields x Virus	Yield x Girth	Girth x Virus	Yield x Virus Eliminating Girth	N
*1954-55	+ 0.1997	+ 0.2285	+ 0.0756	+ 0.1879	157
*1955-56	+ 0.3214	+ 0.3226	- 0.0195	+ 0.3462	274
1956-57	+ 0.1872	+ 0.3092	- 0.0450	+ 0.2116	386
1957-58	- 0.0279	+ 0.3808	- 0.1760	+ 0.0430	524
1958-59	- 0.1376	+ 0.4148	- 0.1803	- 0.0701	606

Before Mirids were controlled.

The relationship between yield and duration of infection became less marked in the crop season when control measures were applied, and has since disappeared. Indeed, in the 1958-1959 crop season there was a slight tendency for the oldest infections to outyield the most recent. Furthermore, in an adjacent farm, which was in a similar condition in 1953, and did not until recently receive insecticidal sprays, the level of virus infection is now high and the cumulative effects of virus, Mirid damage, and die-back over the years have made the farm unproductive. Thresh (1958) stated that the infected trees were more susceptible to Mirid attack. Many of the trees are moribund and a dense under-growth of grasses and small shrubs has followed the destruction of the canopy. There is no indication of soil or other environmental differences between this site and the one described above. In the sprayed plot, regeneration has proceeded without checks by further Mirid damage, and much of the present crop is borne on growth made since 1956. The yield in the 1958-1959 crop season was 800 lb. of dry cocoa per acre. This should be compared with the national average production which is less than 300 lb. of dry cocoa per acre.

b) Oluwo observation plot

Regular symptom observations were started in 1957 on a plot of randomly planted cocoa at Oluwo in the Ibadan Area of Mass Infection. The number of infected trees increased from 51 trees at the outset to 153 in August 1958. Most of the infected trees showed symptoms typical of virus infection and were usually in worse condition than their neighbours. Mirids were universally present though virus infected trees were more severely attacked than healthy ones.

Regular spraying with gamma B.H.C. was started in 195 to control Mirids, and most trees have since made excellent growth. The condition of each tree was assessed before spraying began and at regular intervals after spraying, using a simple scoring system (Lister & Thresh 1955). Yields for the crop season August 1958 to July 1959 were recorded for each tree, and these yields were significantly correlated with girth, and with the condition of the canopy as recorded in August 1958. There was a significant correlation between yield and duration of infection similar to that at Koroboto but after eliminating the effects of canopy condition this correlation disappeared. By comparison, at Oluwo the correlation between yield and canopy condition remained significant after eliminating variation due to girth, and duration of infection. Thus canopy condition is the most important of these factors, and whilst this can be influenced by virus infection, it appears that the condition of the tree is largely determined by the effects of Mirids, for at Koroboto the relationship between yield and infection ceased to exist after canopy conditions improved following Mirid control.

e 2. Correlations between yield, girth, canopy condition and duration of infection at Oluwo Swollen Shoot observation plot

Correlation	Healthy Trees (N = 230)	Infected Trees N = (160)
eld x Girth	+ 0.4667***	+ 0.3429***
ld x Canopy Damage	- 0.4752***	- 0.5600***
eld x Virus	-	+ 0.2575**
eld x Virus. Canopy Damage	-	- 0.0745
eld x Canopy Damage. Virus	-	- 0.5185***
eld x Canopy Damage. Girth	-	- 0.5545***

* = Significant at P = 0.001
' = Significant at P = 0.01

2. The interaction of virus and Calonectria

Four cocoa farms which were naturally infected with virus were chosen at Offa-Igbo near Ibadan, and two were sprayed with gamma B.H.C. to prevent further Mirid attack. In each of these farms selected fan branches on virus free and virus infected trees were inoculated with Calonectria. The technique used (Kay, 1960a) closely simulated Mirid damage and subsequent die-back. Both spread of die-back in the inoculated twigs, and the number of twigs which died to the point of inoculation were greater in virus infected trees. Moreover the results indicate that spread of die-back was greater in virus infected trees in the unsprayed plots, which were subject to continual Mirid damage. At Oluwo similar trials have shown that the spread of die-back is affected by the length of time the tree had been infected with virus, and upon the phase of virus infection. Kay (1960b) has shown in Ghana that there was a direct relationship between the spread of die-back and the virulence of the infecting virus. Preliminary investigations suggested that an adequate water supply reduced the spread of die-back (Kay, unpublished information). An inadequate supply did not stimulate the spread of existing inactive die-back, but promoted the spread of active die-back sites.

3. The effect of virus upon growth

Experiments on young trees at Agodi

A population of 240 young trees was divided into four groups as nearly equivalent in size and condition as possible. Two groups were inoculated with a combination of virulent viruses from Abaku and Egbeda. The flushes on one inoculated group of controls have been damaged each fortnight to simulate Mirid damage. Records of stem diameters indicated that virus inoculated plants had made significantly less growth in eight months than the controls. Most of the inoculated trees had shown the characteristic leaf symptoms of both viruses, and the swellings associated with Egbeda, and in many cases terminal swellings had destroyed the growing point. Virus infection had a striking effect on flushing as the number of new shoots had decreased by 60% in July 1959 and by 80% in August, when compared with controls. The artificial image treatment has so far had little effect on growth. The difference in rate of flushing between treatments was most striking at the major growth periods in October and April.

he effect of environment on virus and Calonectria

number of experiments were designed to give precise infor-
ation on the effects of virus on cocoa under different cul-
ural conditions (Longworth, 1960).

The first experiment consisted of a factorial combina-
ion of presence and absence of irrigation, and fertilizer
pplication, and each plot contained healthy plants and others
noculated with mild, and severe virus. The area was heavily
ulched, and shaded for the first dry season after planting,
nd these two factors were apparently sufficient to preclude
ny effect of irrigation. The reduction of growth caused by
irus was significant and virus has also supressed height of
he seedlings and the number of leaves produced. When most of
he infected plants were showing symptoms, half of the plants in
he virus treatments were inoculated with Calonectria. Eight
onths after inoculation the seedlings were removed and the
ength of the lesions measured. It was noted that lesion length
as significantly greater in virus infected plants (P = 0.01).
ean lesion length in healthy controls was 29.9 mm. and in mild
nd severe virus infected plants was 31.0 and 38.8 mm. respec-
ively. This has obvious relevance to the situation in the field
s Thresh (1960) has shown at Koroboto and elsewhere that virus
nfected mature cocoa will regenerate and yield satisfactorily
f maintained free from Mirids and associated die-back fungi.

The second experiment consisted of similar virus and
alonectria treatments superimposed upon the plots of a facto-
ial layout involving shade and fertilizer treatments. After
lanting and throughout the first dry season shade promoted
rowth, but later the situation was reversed, and the greater
rowth in exposed conditions has continued. Virus supressed
rowth, and significant reductions in stem diameter, seedling
eight and leaf number were recorded. However, the supression
s greatest under exposed conditions (Table 3). The Calonec-
ia lesion lengths were greater in the virus treatments, but
this case the differences were not significant.

3 Effect of mild and severe isolates of Virus on stem diameter under exposed and shaded conditions

Category	Healthy	Mild	Severe	Total
Mean Stem Diameter (cm.) in Shaded Plots	2.36	2.22	1.98	6.56
In unshaded	2.84	2.64	2.00	7.48
Total	5.20	4.86	3.98	14.04

In both experiments, the number and length of lateral roots was recorded on seedlings which were removed for observation of the Calonectria lesions. Whilst root length and number of roots were reduced by virus (P = 0.1), in the second experiment the supression was relatively smaller under shade than in exposed plots. This interaction was significant though the reduction in total root length in shaded plants was not.

5. The effect of virus on growth of young cocoa in the field

The second seedling experiment described above involved a large number of guard plants, and in November 1958, 360 of these were selected and used in an ancillary experiment. The seedlings were divided into three groups, at random, and one group was retained as the healthy control. A second group was inoculated with a virulent isolate of cocoa swollen shoot virus from Egbeda in November 1958 (T1) and the third group was inoculated in February 195 (T2), when most of the seedlings inoculated at T1 were showing symptoms.

Frequent records were made of leaf number, stem diameter, seedling height, and on the appearance of symptoms. Further, half the plants were removed in July 1959 for a detailed record of air-dry weights of stem, taproot and lateral root, and the number of lateral roots.

By May 1959, the seedlings infected with virus were significantly smaller than the healthy controls. The early inoculations caused the greatest reduction in growth, and the mean monthly increase in height since T1 was 7.6 cm. compared with 10.4 cm. for the seedlings inoculated at T2 and 12.9 cm. for the controls. Similar effects were noted on stem diameter and leaf number.

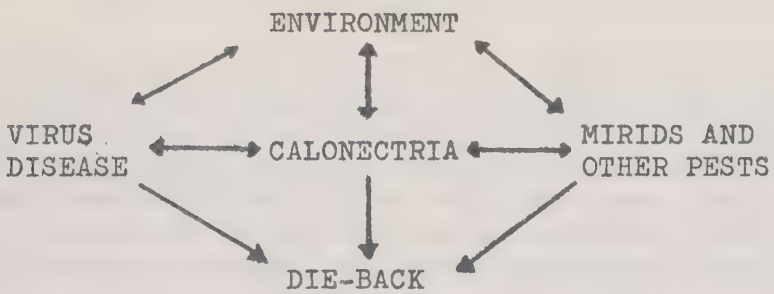
Table 4 The effect of a virulent isolate of Swollen Shoot virus on stem and root growth

Category	Mean Wt. of Stem	Mean Wt. tap root	Mean Wt. Lateral roots	Mean Wt. Total root	Stem/ Root Ratio
Healthy Controls	248g.	74g.	16g.	90g.	2.76
Inoculated at TI (Nov. 1958)	174g.	53g.	11g.	64g.	2.72
Inoculated at T2 (Feb. 1959)	195g.	63 .	11g.	73g.	2.67

The results for the sample of trees which were uprooted and ghed indicate that virus caused a general reduction in growth, there was no change in the stem/root ratio. Whilst there was marked reduction in number and weight of lateral roots in the us inoculated seedlings as was indicated in the previous ex- iments, the mean weight of total roots was reduced.

DISCUSSIONS AND CONCLUSIONS

Many factors contribute to the unthriftiness of cocoa in tern Nigeria. Among these are the viruses causing swollen ot disease of cocoa, and Mirids principally Sahlbergella gularis Hagl. Their interaction in causing die-back of the oa tree has been the subject of investigation at W.A.C.R.I. dan. The results obtained so far have greatly assisted in re- ving this problem, and the following diagram is proposed to ustrate the interplay of factors leading to die-back:



application of insecticidal sprays to cocoa farms infected h virus brought about striking improvements in growth and ld. This led to the suggestion that Mirids and the associa- Calonectria die-back largely determined the condition of us infected cocoa. In fact Thresh (1957) stated that in the ervation plots at Koroboto, and elsewhere in the Area of Mass ection, virus is rarely, if ever, solely responsible for the th of trees. Moreover in the areas of Mass Infection where dication measures were abandoned in 1950 (Lister & Thresh, 7) the cocoa has not died out as was expected.

At Koroboto and Oluwo there was a significant correlation ween decrease in yield with duration of infection, and this ationship was reduced and finally eliminated at Koroboto after years following Mirid control measures, and at Oluwo by

removing the effects of canopy condition in analysis of the data. These results emphasize the importance of Mirid spraying, and indicate that the combined damage caused by Mirids and virus is greater than that caused by either occurring alone.

Mirids when feeding may kill young green tissue by injecting a toxic saliva (Goodchild, 1952) and in woody tissue these lesions provide entry points for C. rigidiuscula. Williams (1953) suggested that virus infection may predispose trees to attack by Mirids. Continued Mirid attack destroys the young regenerating tissue, and introduces further Calonectria. This cumulative process (Clayton, 1958) severely weakens the canopy and may destroy it completely, particularly in combination with other factors. Virus infection, for example, increases leaf fall, and generally reduces growth, (Ponette, 1948. Goodall, 1949). The present studies have shown that virus infection reduces the number of growth flushes produced. The greater numbers of Mirids on infected trees are therefore concentrated upon a smaller number of flushes and this further weakens the regenerative capacity of the tree. Longworth (1960) and Kay (1960) have shown that the spread of Calonectria is greatly influenced by the presence of the infecting virus and its virulence and also by the phase of its action upon the cocoa tree.

Where virus infection, Mirid damage and Calonectria infection occur together the direct effects upon the trees are severe, and in addition there are indirect effects which combine to aggravate this situation. Increased exposure to light intensifies the effect of virus upon the tree, and also encourages the formation of a ground vegetation, and the cocoa root system which had been weakened by virus must compete with this for nutrients and soil water.

The cocoa growing areas of much of the Western Region can be considered marginal. The mean annual rainfall at Ibadan is less than 50" and the decline of virus infected cocoa in this Region which is attacked by Mirids is particularly severe in the dry season, and Mirids are present in quite large numbers at this time (Williams 1954, Donald 1957). Kay (unpublished information) has shown that the spread of active Calonectria die-back is increased by an inadequate water supply, and the competition between the reduced root system and the ground vegetation is intensified at this period of water stress.

The cumulative effects of these factors over several seasons combine to cause severe die-back and often death of the cocoa tree. This decline is often accelerated by farmers whose cultivation of the crop may be confined to harvesting periods, and in absence of proper maintenance the farm may become unproductive especially if the area has been interplanted with food crops.

These preliminary results afford some explanation of the poor
lition of much of Nigerian cocoa, and suggest the syndrome which
been described. The most important contribution is a realisation
he relative importance of Mirids and virus in this situation, and
s clear that in Nigeria, and particularly in the areas of Mass
ction, great benefits would accrue from general application of
d control measures.

SUMMARY

Until 1956 it was almost impossible to separate the effects
Mirids and virus in causing dieback of cocoa, and the degenera-
n of Swollen Shoot outbreaks was attributed to virus. It was
until chemical control measures were introduced against Mirids
1956 that it was realised that Mirids and the associated dieback
gus Calonectria rigidiuscula (Berk & Br.) Sacc., largely deter-
ed the condition of virus infected cocoa farms in Nigeria. Spec-
ular improvement in growth and yield followed control operations.

An important part of the research programme at WACRI, Ibadan,
been a study of this problem, and its inter-relation with the
ironment. This has involved in part a combined approach of the
hology, mycology and agronomy sections, and the present paper
lines results obtained to date.

RESUMEN

Hasta 1956 fue casi imposible separar los efectos de los Mi-
os y los virus como causantes de la muerte regresiva del cacao,
l empeoramiento de los brotes de "Swollen Shoot" se atribuyó
irus. No fue sino hasta 1956 cuando se introdujó medidas de
trol químico contra los Miridos que se tuvo conocimiento que
os y la muerte regresiva causada por el hongo Calonectria
idiuscula (Berk & Br.) Sacc., determinaban en su mayor parte
estado de las fincas de cacao afectadas de virus en Nigeria.
obtuvo mejoras espectaculares en crecimiento y rendimiento
pués de las operaciones de control.

Una parte importante del programa de investigación de WACRI
Ibadan ha sido el estudio de este problema y su inter-relación
el medio ambiente. Esto ha requerido en parte un enfoque com-
ado de las secciones de patología, micología, y agronomía, y
e articulo presenta los resultados obtenidos hasta la presente
ha.

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RESULTS FROM PRELIMINARY STUDIES OF SOME ASPECTS OF THE RELATIONSHIP OF INSECTS TO CACAO PRODUCTION IN COSTA RICA: A SECOND PROGRESS REPORT*

R.D. Shenefelt**, M.J. Stelzer***, and F. Lara E.****

Insects affect cacao in many ways. At no time are the pl free from the influence of the many kinds of abundant six-leg creatures which are associated with them. Soil insects may de troy rootlets on germinating plants and continue to do so as plants age. The wounds which they create may serve as infecti courts for various root rots or other disease-causing organis No portion of the tree above ground escapes the effect of bus immature or adult insects. The trunk may be quickly invaded b borers or bark beetles whenever the vigor of the tree decline Leaf-hoppers, aphids and other sucking insects debilitate the tree through sucking its juices. Chewing insects such as cate pillars, beetles and leaf-cutting ants consume the leaves. Te nals may be mined by round-headed borer larvae. Thrips rasp a the flowers or leaves and tree-hoppers may block up the condu ing tissues of the flower pedicels by laying eggs in them. Th surface of the pod may be mined by lepidopterous larvae and t seeds by other insects. Like their underground counterparts, sects living above the soil may open the way for diseases or serve as vectors and introduce them directly. In brief, the c tree is subjected to much pressure by insects (as are all oth kinds of plants). It must grow and produce in spite of the to taken of its substance by the voracious pests.

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** Professor

*** Former Research Assistant

**** Research Assistant

Department of Entomology, College of Agriculture, Univer of Wisconsin, Madison 6, Wisconsin, U.S.A.

However, the cacao tree also has its insect friends. With- insects it is doubtful that the tree would set fruit. Parasi- and predaceous insects help to destroy its insect enemies. ers and other types of insects assist in destruction of dead aches and fallen trees and thus in maintaining an environment n that the plant has the right habitat in which to develop.

Not only is the cacao tree affected directly by the activi- s of insects but also indirectly. For example, insects are the ginal silviculturists and may have a lot to say about the kind trees which can be grown for shade. They may strip shade trees that the canopy has little effect in reducing the intensity of light.

Even the products which are obtained from the tree may be ru- d by insects. Cacao beans may be ravaged by the cacao grain moth mond moth). Candy bars are sometimes infested by the Indian meal n or small beetles.

Now man has found the cacao tree useful and wants its beans chocolate. He has planted the species here and there. Finally has come to realize that other biologic agents are offering him ff competition. It is only lately that he has started out to d ways and means to protect the tree from its enemies and to ly make an assessment of their influences.

But how can such an assessment be made,i.e. what is a cacao really capable of producing? Nobody can answer this question use nobody really knows what an ideal environment for cacao is et.

In studying the influence which insects have upon the tree we only a few courses open to us. One is to isolate the tree from insects and hand pollinate it. This is not easy when one consi- that insects burrow through the ground, crawl and fly, and many of them, such as thrips, are very tiny. The problem is of excluding insects without so upsetting the environment that ree declines. If this can be accomplished, then such isolated s may be compared in productivity with 'open-grown' ones.

A second approach is to cover certain portions of the tree by s of cages. By introducing insects in known numbers into a of the cages the local, direct effect of insects may be deter- d.

A third approach is to study the effects of reducing (or eli- ting) (or 'controlling') the insects by means of insecticides ome trees and comparing these trees with untreated trees.

A fourth approach is to try to find trees infested by a particular kind of insect and others which are not harboring this species. Then comparisons may be made between the two. Of course, to be absolutely valid, the two tree populations would have to be the same age, have the same genetic constitution, be in exactly the same environment and have been subjected to the same conditions in the past.

Often combinations of the four methods are tried.

Because of the difficulties encountered and the problems created by variability, replications are necessary and conclusions must be drawn with caution. Nevertheless, one must look for leads in order to know what kind of an experiment to set and to obtain clues as to objectives. This is done by means of preliminary observations and tests.

The observations and results discussed in the remainder of this paper come mostly from such preliminary studies. As such, they are not to be regarded as final but as pointing the way.

We wish to discuss three phases of our work today. These are:

1. the relationship of insects and Cherelle Wilt;
2. the effect of insecticide application upon yield; and
3. possible relationships between insects and Cushion Gall.

Naturally these subjects cannot be covered in detail at this meeting. However, the details should appear in print shortly.

INSECTS AS A FACTOR IN PRODUCTION OF CHERELLE WILT

The phenomenon known as Cherelle Wilt in cacao literature is so well known that no description of it need be included he Hitherto this has been regarded as a physiological response of the cacao tree due to overstress caused by the setting of too much fruit. That it is not entirely such is indicated by results obtained both by cage studies and insecticide treatments.

In Costa Rica the insects found most commonly feeding on the pedicels of flowers and tiny fruits belong to the order Hemoptera. One of the most abundant is the treehopper Amastris

gens F. Two species of leafhoppers and the aphid Aphis gossy- Glov. also must be mentioned here. All feed on the pedicel, re- ing juices and wounding the tissues. Amastris also lays its eggs the stalk of the small pod, causing further occlusion of vessels.

Cages were placed over 373 pods at a very early stage in deve- ment. One hundred twenty-one served as control cages, 178 recei- a specimen of Amastris, 62 received one or the other of the hoppers, ten received colonies of Aphis gossypii and eight had cellaneous sucking insects. As far as possible, paired cages with insects and the other without) were set up on the same nch or on the trunk of one tree. Records of numbers of pods wilt- rates of growth, time required to reach maturity, numbers be- ing diseased and wet bean weights were obtained.

Summarizing the results shows the following:

The percentage of pods which wilted was greatly increased when the insects were present. In the insect-free cages 12.4 per cent wilted. In those with insects 38.5 per cent wilted. This represents a 310 per cent increase in Cherelle Wilt when insects fed upon the developing pod or its pedicel. Put ano- ther way, insects were responsible for about two-thirds of the wilting. Percentages of wilt were higher in both insect-free and insect-treated cages in a shaded area as opposed to one without shade.

Developing Cherelles are extremely susceptible to insect attack early in their development. For example, 51.9 per cent of those which averaged 0.6 cm. in length at the time of cag- ing and were subjected to damage by the insects wilted. Only 15.5 per cent of Cherelles averaging 1.4 cm. at caging and no- ne of those over two cm. in length at caging died. These fig- ures are from an area without shade but the figures from the shaded area are of the same general order. The highest percen- tage of wilting in control Cherelles in cages also occurred in the smallest size class.

This means that any attempts to reduce Cherelle Wilt due to attack by sucking insects must be aimed toward protection of the very small fruit.

The pods harvested from cages in which insects had been placed required about a week longer to reach their maximum length and maturity, were about 3.5 per cent shorter, and the average wet weight of the beans produced was roughly five per cent less than that of the controls.

A separate analysis made of paired cages only gave figures of the same general magnitude.

When the increase in Cherelle Wilt is added to the reduction in yield, the influence of insect feeding upon the young pods becomes one which must be seriously considered.

Further evidence of the role of insects in Cherelle Wilt is to be found in the results obtained from the use of insecticides.

INSECTICIDES AND CACAO PRODUCTION

The use of insecticides as a means of controlling insect pests in cacao has for the most part been neglected in the cacao-producing countries of the Western Hemisphere. The principal objections raised against their use have been due to the possibility of killing the insect pollinators (and consequently no fruit production) and to the possibility of upsetting the natural 'balance' created by the activities of beneficial forms such as insect-parasites and predators.

Studies were started at Finca La Lola, Zent and Quepos in 1958, to determine the effect of Dieldrin on cacao production. The insecticide was applied, at the rate of approximately 2.25 g/tree of actual, at monthly intervals alone, and in combination with Bordeaux mixture. Bordeaux was also applied alone and an untreated block of trees served as the control. DDT was similarly studied at La Lola. At Zent and Quepos the treatments are not replicated, but at La Lola three replicates of each treatment were established. When the tests were initiated it was anticipated that at least two years would be required for difference to be created between treated and control trees and be properly reflected in yields.

Direct comparisons of the results obtained in the three areas were complicated by variations in climate, soil, age of trees under treatment and spray equipment used. While no final analyses can be made as yet (nor will time permit the mass of figures which we have to be presented here), the following items may be of interest.

Within each area comparison of the 1958 and 1959 yields on a per tree basis for the April through September period, and utilization of the percentages of increase or decrease among the plots during the second year as a basis for indications of trends show some interesting things.

ola

Comparison of the 1958 and 1959 yields at La Lola from to 50- year-old seedling trees gives the following: In 1959 yield from the check increased to 5.1 times that of 1958. g this 510 per cent increase as a standard, i.e., as 100, the tive improvements shown in other plots were: DDT--105; DDT + eaux--108; Bordeaux alone--148; Dieldrin--155; and Dieldrin + eaux-196.

os

At Quepos figures on per tree yield of pods for the April ugh September periods on 12-year old clonal cuttings are:

	1958	1959	% increase
Control	4.90	7.56	51
Bordeaux	9.26	16.04	73
Dieldrin + Bordeaux	6.97	14.86	115
Dieldrin	7.42	21.81	194

Cherelle Wilt on a per tree basis at Quepos showed (on the lute pod basis) increases as follows: Check--26%; Dieldrin + eaux--11%; Bordeaux--8%; and Dieldrin--25%. (If the control 0, Bordeaux = .307; Dieldrin + Bordeaux = .422; and Dieldrin = .

Of the pods recognized as being set, the following percenta- were harvested: Control--30%; Bordeaux --50%; Dieldrin + Bor- x--30%; and Dieldrin--35%.

The totals for April 1958 through September 1959 at Quepos enlightening. (Each plot contains 100 trees).

	Total pods set	Pods harvested	% of set	Pods wilted	% of set	Black pods	% of set
rol	5832	2135	36.5	3508	60.3	189	3.2
eaux	7713	3665	47.5	3830	49.7	218	2.8
drin + rdeaux	8515	3218	37.8	5104	60.0	195	2.3
drin	10196	4093	40.1	5838	57.2	265	2.6

Expressed on the basis of the check as 100% the following percentages occur:

	Pods set	Pods harvested	Wilted pods	Black pods
Control	100	100	100	100
Bordeaux	132.5	172	110	115
Dieldrin + Bordeaux	146.5	151	146	103
Dieldrin	175	193	165	140

It should be observed that these percentages are based on absolute numbers as compared to the control. The gain in wilted and black pods in the other plots is due to increase in number of pods set. The actual percentages wilting or infected by Phytophthora are less than the percentages in the control.

During September 1959 (the last month of the period involved) the Dieldrin plot out-yielded the control by 320% in number of pods harvested.

Zent

At Zent the results, from plots containing both 12-year-old clonal stock and 45-year-old seedlings, are quite interesting and are also difficult to interpret. The figures are complicated by the fact that part of the trees in certain plots were washed out by a river, thus making certain assumptions and adjustments necessary.

The figures for total number of pods harvested per tree from April 1958 through September 1959 are:

	Clonal	%	Old trees	%
Control	36.3	100	33.5	100
Bordeaux	36.3	100	45.3	135
Dieldrin + Bordeaux	31.9	88	63.2	186
Dieldrin	34.8	96	69.6	208

rcentages of fruit harvested (old and young trees combined): trol--83.4; Bordeaux--88.6; Dieldrin + Bordeaux- 88.7 and ldrin--89.5.

Study of the plot yields showed that at first (before the fluence of insecticide could have been expressed at all in pods) the yields were quite different in the four plots. plots in order of placement were Dieldrin, Dieldrin + deaux, Bordeaux and control, and the order of early yield was from low to high Dieldrin, Dieldrin + Bordeaux, control, deaux with the Dieldrin plot yielding only about 75% of control at the start. Comparing the 1958 and 1959 April ough September yields and expressing the 1959 yield in ms of the 1958 yield for the same plot shows vividly what occurring.

	Clonal trees			Old trees		
	1958	1959	% change	1958	1959	% change
trol	100	94.2	-5.8	100	42.4	-57.6
deaux	100	89.5	-10.5	100	72.5	-23.5
ldrin + ordeaux	100	141.7	+41.7	100	81.4	-18.6
ldrin	100	153.3	+53.3	100	135.4	+35.4

The order of high yields is being reversed. Since these ts lie adjacent to each other and have received the same tre- ents excepting for the insecticide and fungicide, the changes ch are being established cannot be due to climate differences.

temic Insecticides

Data for the two small plots of 12-year-old clonal trees ated by one injection with systemic insecticides in March, 9, together with those for their respective control plots are August 1958 through December 1959:

	Pods harvested	Pods wilted	Total pods	% wilt
met	465	139	614	23
trol	321	81	402	20
ram	437	129	566	23
trol	349	83	432	19

The Thimet-treated trees yielded 45% more harvested pods than their controls while the Tetram-treated trees yielded 25% more than their controls.

The data from the three areas indicate a number of things

1. The application of Dieldrin does not reduce pollinat On the contrary, more fruit seem to be set when it is us (One might almost conclude that Dieldrin is a good 'polli ting' agent. Of course, what the insecticide actually doe is to allow the pollination which occurs to be expressed, i.e., fewer of the pollinated flowers are 'blasted' befor it can be seen that they have set fruit).

2. The application of Dieldrin appears to reduce the re lative amount of Cherelle Wilt. A part of Cherelle Wilt i manifestly due to insect attack and it is undoubtedly in control of this portion that the gain is registered. Cer- tainly the control trees at Quepos appeared to have littl reason for having a high 'physiological' wilt when the nu ber of pods they were carrying was compared to the number which the Dieldrin-treated trees proved capable of suppor ting.

3. There is some evidence that bean weight per pod is i creased by treatment with insecticide. Bean weight of po at Quepos between Dieldrin and control appears to be of a bout the same order of difference as that found in the pr tected versus insect-exposed pods in the Cherelle Wilt-c studies, but we have only very preliminary figures from t latter portion of the test at Quepos.

4. That the process of establishment of differences in elding capacity is still being undergone can readily be s by a study of the graphs of period to period yields. The ferences between treated and control trees are becoming ater.

5. The differences between Quepos and the East Coast are probably due in part to the duration of protection by th insecticide. We know that the 30-day spray application c cle is not adequate to provide full protection through r sidual action. In the drier climate at Quepos the insect de is undoubtedly protecting the trees for a greater par of the time.

6. In view of the results obtained thus far from these liminary tests, it appears desirable to work on the spac

of insecticidal applications, on their timing, and on various dosages with the idea of obtaining the maximum profit. Costs of insecticide and application must be balanced against extra income derived.

The systemic insecticides deserve further testing, using means of application other than tree injection.

Before leaving this subject it should be emphasized that the entation of preliminary results does not constitute a recom- ation. We have not gone into cost aspects, nor have residue yses with Dieldrin been made, nor have taste tests been run. data presented do, however, show that cacao production is nitely affected by the activities of insects and that the ject is worthy of intensive investigation.

POSSIBLE RELATIONSHIPS BETWEEN INSECTS AND CUSHION GALL

A number of important factors must be considered in study- the relationships which may occur between insects and mites Cushion Gall. It is very difficult to so cage complete trees all insects are excluded. If one cages flower cushions on- free-living insects come to the treated plant from unknown es. Furthermore, no backgrounds of former insect populations he plants are available for comparisons, nor are the ancesto- f the plants usually known. For these reasons conclusions be drawn with extreme caution and results be considered as iminary until transmission is obtained by following a pres- ed series of tests to obtain complete proof. The rules for ing involve Koch's postulates and are given by Leach on p. of his book "Insect Transmission of Plant Diseases".

How might insects be related to Cushion Gall?

a) They might cause a hypertrophy of plant tissue through introducing substances causing the plant to develop the gall at the local site.

b) They might serve as vectors of some organism which in turn causes the gall to form.

c) They might make wounds through which the causal organism might gain entrance.

We have no proof that whatever is responsible for Cushion is transmitted by insects, nor that insects themselves are

directly responsible. But we have made numerous preliminary tests and observations. The tests have mostly involved collecting insects feeding upon galled cushions and caging them over flower cushions on healthy plants.

As no classification of Cushion Gall types was available in 1952 when this work was started, one was developed. This is somewhat different than that worked out by Dr. Hutchins.

Insects associated with flower cushions or Cushion Gall with which we have worked are: Macistorhinus sp. (Homoptera: Pentatomidae); Horiola arcuata F. (Homoptera: Membracidae); Amastris obtegens F. (Homoptera: Membracidae); Clastoptera globosa Fowl. (Homoptera: Cercopidae); Polana sp. (Homoptera: Cicadellidae); Gypona sp. (Homoptera: Cicadellidae); Dysmicoccus brevipes (Ckll.) (Homoptera: Pseudococcidae); Ferrisiana virgata (Ckll.) (Homoptera: Pseudococcidae); Aphis gossypii Glov. (Homoptera: Aphidae); Toxoptera aurantii (Fonsc.) (Homoptera: Aphidae) Conopia sp. near theobromae Busck (Lepidoptera: Aegeriidae); Entomobrya corticalis Nicolet (Collembola: Entomobryidae); 'mites' (Arachnida: Acarina)-- a number of different kinds; and the following ants (all Hymenoptera: Formicidae: Myrmicinae) Solenopsis geminata F., Solenopsis (Diplorhoptrum) picea Emery, Pheidole flavens Roger and Crematogaster limata Fr. Smith.

The pentatomid, one of the membracids, the cercopid, the two leafhoppers, the two aphids, the mealybugs and several species of mites have been transferred from galled cushions to healthy ones. Clastoptera has also been placed upon plants to see if it produced the gall directly.

Galls of one kind or another have developed upon cushions being fed upon by Clastoptera globosa, in one experiment by Dysmicoccus brevipes, in one instance where Toxoptera aurantii was involved (but the tree was also heavily attacked by Clastoptera during the course of the experiment), and also where mites where under test. In no instance are the relationships clear.

The moving of certain insects to 'healthy' cushions on both trees showing Cushion Gall and those free from it also produced only indefinite results.

At the present time the finger of suspicion points most directly toward Clastoptera globosa.

It is very evident that closely controlled, detailed experiments of several different types will have to be made to clear up the relationships.

FIG. 1

Control plant. This photo shows the type of budded plants used in this experiment. This is the same aspect as given by the plants sprayed with plastic resin.

FIG. 2

Example of plants stumped one week prior to transplanting.

FIG. 3

Plant inclosed in a polyethylene bag. This bag is moisture tight and tied with string to the stem just above the bud union.

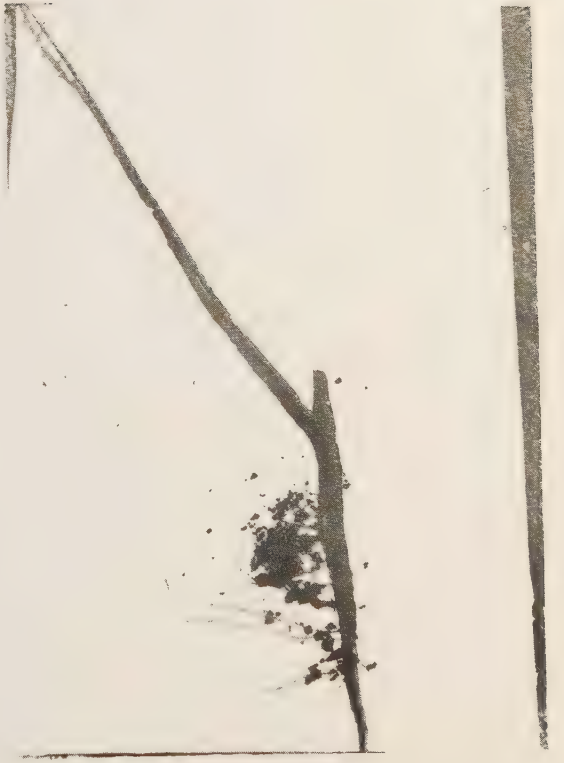

FIG. 4

Defoliated plant. The leaves were removed one week prior to the actual transplanting.

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SUMMARY

This paper is a second progress report on preliminary
ies on the harmful and beneficial insects associated with
o. A relationship between certain treehoppers, leafhop-
and an aphid which feed on the pedicel of young fruits
the wilt of young pods was established.

Preliminary trials with insecticides have indicated that
drin does not reduce fruit set and appears to reduce Che-
e Wilt; there is some evidence that bean weight per pod
ncreased with insecticides. Certain systemic insecticides
to be promising. The relationships between many insects
mites and Cushion Gall have been studied.

RESUMEN

Este artículo es el segundo informe de progreso en estudios
iminares sobre insectos dañinos y beneficiosos asociados con
o. Se estableció una relación entre ciertos insectos áfidos
se alimentan de los pedicelos de los frutos jóvenes, y el mar-
amiento de las mazorcas jóvenes.

Ensayos preliminares con insecticidas han indicado que Diel-
no reduce el cuajamiento de frutos y parece reducir el mar-
amiento de frutos jóvenes; hay alguna evidencia que el peso
mazorca aumenta con el uso de insecticidas. Algunos insec-
das sistémicos parecen ser promisorios. Se ha estudiado la
ción que pueda existir entre insectos ó pulgones y las agallas.

SUMMARY OF DISCUSSION

Dr. D.R. Glendinning (WACRI)

There is known to be some loss of young cherelles by fungal attack, and we hear from this paper that insect attack can cause losses. In conditions where the number of pods set is greatly in excess of what the tree can carry, and where Cherelle Wilt in consequence is heavy, such losses due to insects and diseases attacking very small cherelles will serve only to reduce the proportion of Cherelle Wilt so that the total of Cherelle Wilt plus these losses equals what would normally have been lost by Cherelle Wilt alone. These losses are thus of no significance. However, where the number if pods set on a tree is lower in relation to what it is able to carry, such losses may constitute a reduction in yield.

Dr. Chapman, in presenting the paper, suggested that the greater yields recorded from the treated trees in the table at the bottom of page 6 may have been due to the reduction in losses of cherelles due to insect attack. In fact, it appears from the tabl to be otherwise; the total setting on the treated trees is greate perhaps due to their being in better general condition and floweri more freely, and the Cherelle Wilt is a fairly constant proportion The greater yields are thus due to the better condition of the tre or the greater setting, and not to any alteration in Cherelle Wilt

TRANSMISSION OF THE CUSHION GALL DISEASE OF CACAO*

August M. Gorenz**

INTRODUCTION

The cause of Cushion Gall of cacao is still not known with abute certainty although the disease has been present in Nicaragua some time (3). Among the possible causes that have been suggesare included insects or mites, a virus, physiological disturbanwith emphasis on nutrition, bacteria, or a fungus. Of these eir the virus, fungus or bacteria appears the most probable and in order named. Diseases with similar symptoms occur in other spes of plants that have been proved to be caused by each of these. ent detailed surveys by Hutchins (1) could be interpreted to inate that a transmissible virus is the probable cause of the dise and that it is systemic in the plant.

This report refers to the type of Cushion Gall named "greennt gall" by Hutchins (2). The work was done with the active aid support of Dr. Stephen S. White, Horticulture Advisor of the M to Nicaragua.

The only symptom of the disease that has so far been identid in bearing trees is the production of the flower-cushion galls. terminal shoot or leaf symptom has been found. The gall is for- by the production of hundreds of bud-like flower initials over hort continuously branching projection growing from the original hion. These are much greener than normal flower buds and do not ngate, resulting in a tight, rounded, but verrucose gall that ords shelter to many kinds of small insects. Some of the buds, ecially those with the green points, may in fact be abnormal stem s and the green points rudimentary leaves or the stipules that ur one at each side of the base of the leaf petiole. When some ls are first forming a few flower buds may pass the abnormal pridial stage, the stalk elongate normally, and even produce a pod.

Some of the largest galls, which are always of a non-flowering e, have been found at the base and near forks of suckers originag from old plants, especially when they are cut back. The active

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*Work carried out at the Estacion Experimental Agropecuaria "La Calera" of the Ministerio de Agricultura y Ganaderia de Nicaragua.

**Plant Pathology Adviser, USOM/Nicaragua, Managua, Nicaragua.

production of galls both in number and size coincides with the mo active growth of the cacao plants in the rainy season. The galls frequently die back at the end of the growing season but often st anew the next year. Injury to the galls from insects, including some boring types, is a major factor in causing them or parts of them to die prematurely. Flower production in following years is reduced or nil in the cushions where galls have been produced but continued on the new growth of terminal branches.

Due to the rapid spread of the disease in some areas increas attention has been focused on it in all cacao growing countries i which it occurs. Since cacao is a tree crop and also since Cushio Gall can normally only appear after the tree starts flowering any research on this disease has to be done on a long-term project ba sis. No report of experimental transmission of this disease had been published to the author's knowledge in August, 1959.

TRANSMISSION ATTEMPT

Methods

A preliminary attempt at transmission of the disease was ma on February 4, 1958. Branches with young active galls were obtai from Valle Menier, near Nandaime, Nicaragua. A small group of thi ty cacao trees at La Calera planted by the Horticulture Departmen in 1954 and without symptoms of the disease were used as the expe mental area. Only three trees were used in this first trial. They were treated as follows.

Tree No. 2: three bark grafts on different branches using pieces bark with galls.

Tree No. 3: seven bark grafts also using pieces of bark with gal

Tree No. 23: two galls placed in direct contact with active flowe cushions and two attempts to graft small galls, all different branches.

Ordinary white first-aid adhesive tape was used as wrapping in al cases.

Results

Of all the grafts made only two on Tree No. 3 had small part of the grafted bark that took successfully. All plants were exam at intervals in the following months.

(i) On September 26, 1958, 235 days after being inoculated, distinct small galls up to nearly one inch in diameter were observed on Tree No. 23 at or near the points of treatments and up to twenty inches directly below on the trunk. Tree No. 3 had a few small, enlarged cushions but none with the typical greenpoint Cushion Gall flower-buds.

(ii) On November 10, 1958, 280 days after inoculation, the following results were observed on the trees:

No. 2: No Cushion Galls on this nor on any untreated trees in the planting.

No. 3: This tree has always been an abnormally heavy flowerer. Four grafts locations on different branches showed no galls. Small, possible, but atypical galls were found in the following locations: two closely above and below an unsuccessful graft; one to the side and one above a partly successful graft; and one on the side opposite an unsuccessful graft.

No. 23: Distinct, typical galls up to one inch in diameter appeared in flower cushions in the following locations, each treatment being on a separate, major branch but not over six inches from the main trunk.

a) Gall on cushion that had a gall placed in contact with it, along with one gall two inches above and another two inches below.

b) Gall at point of contact and also with a gall two inches below and another two inches above on the opposite side. Eight galls occur scattered on the trunk up to about twenty inches below the treatment, but only on the side directly below this branch.

c) Gall three inches below gall-grafting attempt.

d) Gall one inch above gall-grafting attempt: this was so close to trunk that no flower cushions lie in-between.

On this same tree are two main branches and one large sucker were not treated: No galls occur on any of them or on the side he trunk below them.

(iii) The status of these transmission attempts as of July 23, 1959 is reported because of an unexpected new development:

No. 2: As before; no galls on this or any untreated tree.

No. 3: Two positive, typical and actively growing galls appeared four inches below in direct line from one of the

visibly-unsuccessful graft attempts. This is one of t grafts reported as having a small atypical gall closel above and one closely below it. Neither these or any the other atypical galls developed any further after first seen and all dried out. There are no other gall on this tree. One of the new galls was first seen on July 7 and had a diameter of one-quarter inch. The ot her located beside it was listed as a "possible" with new growth of one-eighth inch. It has since enlarged rapidly. This appearance of unmistakeable galls has occurred after an apparently dormant period of 520 day

All of the six other grafts were on lower branches that have been overshaded and are now inactive and dying back.

Tree No. 23: Gall production still occurs almost entirely below th point of inoculation and has not spread to the sucker to the two untreated branches, or to the side of the trunk below them. One gall has appeared five inches above the point of one inoculation. Galls are still only being produced on the side of the trunk under th treated branches and occur all the way to the base of the trunk. Many of the original galls have dried out However, some of them are starting to grow actively again, many have some normal flowers, and one even ha a large pod.

DISCUSSION

Some of the problems involved in obtaining transmission of greenpoint cushion gall have been emphasized by the resultsof these preliminary attempts. In the case of Tree No. 23 the galls appeare seven months after inoculation and transmission was apparently ob- tained in all four branches that were treated. In the case of Tree No. 3 the first active greenpoint galls appeared 17 months after th graft attempt was made. This was in spite of the fact that the gra ted piece of bark did not take when examined visually. This would indicate low concentration and little multiplication, if any, of th infective principle in the bark.

Susceptibility and multiplication would appear to lie in the flower cushion itself. Thus, in the regular harvest practices of c cao plantations such an infective principle could easily be spread from tree to tree by the knife or hook used to cut the pods loose from the trees. Spread by pruning would appear less likely.

The lack of spread of the galls above the point of inoculation special significance. It would indicate internal spread thro- ne phloem elements of the bark. The possibility of growth hor- production in upper galls and its effect on lower flower cus- should not be overlooked. The infected trees have mites, mea- g and aphids along with attendant ants on the galls and cushions. particular types of insects (excluding leaf hoppers) do not seem ansmit the gall or surely there would have been transmission to ons above the point of inoculation.

SUMMARY

The "greenpoint" type of Cushion Gall, consisting of hundreds ud-like flower initials, has been present in Nicaragua for time. It forms in cushions and occasionally at the base and forks of suckers. In a pilot experiment, bark with gall pieces infected trees was grafted upon three healthy trees. In two nem galls appeared after 8 and 17 months at and below the site ne graft. The possibility of transmission through the phloem by harvesting tools is indicated.

RESUMEN

La Agalla de puntos verdes, que consiste de centenares de yemas florales, se ha observado en Nicaragua durante mucho o. Se forma en los cojinetes y a veces en la base o en la eta de los chupones. En un experimento preliminar, se injer- tres árboles sanos con corteza de árboles enfermos con aga- En dos de los árboles sanos se observaron agallas después y 17 meses respectivamente, tanto en el lugar del injerto co- r debajo del mismo. Se indica la posibilidad de transmitir fermedad a través del floema y por medio de herramientas de na.

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TRANSMISSION TESTS WITH CUSHION GALL OF CACAO*

Lee M. Hutchins**

INTRODUCTION

An historical account of cushion-gall nomenclature is given
parate paper on this program, by Hutchins and Siller (5). It
ointed out that at least five different types of galls or out-
ths from the flower cushions of cacao are now recognized.
ish and Spanish names proposed for these types are:

Greenpoint gall, or agalla de puntos verdes;
flowery gall, or agalla floral;
knob gall, or agalla en forma de perilla;
disc gall, or agalla en forma de disco;
and fan gall, or agalla de abanico.

The designation, cushion gall, henceforth should be regarded
collective term. Researches into the cause and control of
ion gall", therefore, should specify clearly the type or
s of gall under study. The five types named above differ one
another both in appearance and in behavior. It may not be
ed in advance that a common cause is associated with any two
em. Only thorough research can point out and establish pos-
causal differences or causal inter-relationships among the
s.

For each gall type under study, it is highly necessary to
mine whether an infective principle, such as a fungus, a bac-
m, or a virus, takes an active part in causing gall initiation
evelopment.

Greenpoint and flowery galls are by far the most important
on gall types now recognized. Both are widely distributed
re capable of rapid spread in a plantation. Transmission
with these two gall types are under way at Turrialba, Costa
and are described here in the form of a progress report.

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rk carried out at the Inter-American Cacao Center, Inter-
erican Institute of Agricultural Sciences, Turrialba, Costa
ca

ant Pathologist, American Cocoa Research Institute, Washington D.C.

TRANSMISSION TESTS WITH GREENPOINT GALL

Pod-stalk inoculations

Transmission tests in which greenpoint gall tissue was applie to the stalks of cacao pods and bound in place with plastic tape were performed in July and August, 1959 (4). Out of 143 such inoculations, about 10 percent were successful and resulted in the development of small but typical greenpoint galls on pod stalks at or near the point of emergence of the stalk from the flower cushio

The incubation period varied from 34 to 57 days for 8 of the inoculations, and varied for longer periods up to 111 days for 6 o the inoculations. In 102 check tests, in which tissues from norma flower cushions in gall-free trees were applied to pod stalks of 13 gall-free trees, there was no indication of gall formation afte 8 months.

The pods, of course, were harvested when fully ripe. In abou 50 percent of the successful inoculations, the gall survived on t living stub of the pod stalk; in the remaining 50 percent, the g died after about 6 months. In all cases of successful inoculatio of pod stalks, the resultant galls were definitely of the greenpoint type, but they remained small, usually less than one-half inch in diameter and in elevation.

Contact inoculation of flower cushions

In a planting of 5-year-old, gall-free trees of clone UF-667 at Turrialba, fresh greenpoint galls collected from heavily disea sed trees in another planting were laid in contact with normal fl er cushions and bound in place with surgical adhesive tape. Two normal cushions on each of 3 gall-free trees, or a total of 6 cushions were so treated on July 2, 1959.

When the wraps were removed in early October, definite green point galls were seen to be forming at 1 inoculation point in eac of 2 trees. In one instance, small galls had begun to develop at 2 untreated cushions several inches below the point of inoculatio By March 1960, after an interval of 8 months from the time of inoculation, a tiny greenpoint gall was seen to be forming at ano ther treated cushion on a third tree. Thus, 3 of the 6 inoculate cushions, 1 for each of 3 trees, are now showing galls, and in on case additional galls have been induced to form at 2 cushions several inches below the inoculation point.

Of some 400 cacao trees in this part of the planting, the only enpoint galls present are those associated with inoculation points the trees that were treated on July 2, 1959. One of these galls now attained an inch in diameter and an inch in height. There be no doubt about the success of the inoculations in transmitting all-inducing agent.

The method employed and the results obtained in these tests are ilar to tests performed in Nicaragua in 1958, and reported by enz (2) at this conference.

l-infusion inoculation of cacao beans

In December, 1959, infusion of greenpoint gall tissues was pre- ed by crushing 60 grams of gall tissue in 300 cc. of tap water. this infusion, 100 cacao beans with testa removed were immersed periods up to 40 minutes, and were then planted in weathered dust. The beans germinated and grew well for many weeks, after ch they were transplanted to pots containing soil, where they were ntained until 5 months old. No galls developed on any of the 100 dlings in this experiment.

A test of this kind was again set up in March, 1960, at which e 50 cacao beans with testa removed were soaked more than an hour a water-infusion of fresh greenpoint gall tissue, and were then nted in sand. Simultaneously, a check test was set up in which seeds were treated with tap water and planted in sand. By May ut 3 weeks after the shoots from the germinated seeds were 6 to nches tall, 3 of the plantlets from inoculated seeds began to deve- typical, young greenpoint galls at the point of union of the yledon stalk with the seedling stem.

sh inoculation tests with cacao half-beans

In these tests, the cacao half-bean technique of inoculation employed. This technique was devised at the West African Cocoa earch Institute (W.A.C.R.I.), in Ghana. One cotyledon of the ao bean is dissected away. A sterile, moist, camel's hair brush passed over a fresh greenpoint gall. Immediately thereafter, the sh is applied to the half-bean and the latter is planted in rile sand.

In our tests, 50 half-beans were inoculated in this way and were nted in pots in a glass house. The experiment was set up in ch, 1960. Within 6 weeks after the plantlets started to develop m the treated half-beans, small but typical greenpoint galls an to develop on 4 of the them at the point of union of the yledon with the stem of the seedling. In 30 uninoculated check nts grown from half-beans, no galls developed.

Inoculations with bacterial isolates from greenpoint galls

Private communications with WACRI pathologists stationed in Ghana, have informed us of their success in isolating pure cultures of a gall-inducing bacterium from galls of the greenpoint type that occur in that country.

Tests of this kind are in progress at the Cacao Center in Turrialba. The bacterial flora associated with the galls is abundant. Several types have been isolated in culture, but as yet we have not succeeded in isolating a type that will induce the development of greenpoint gall when applied to cacao half-beans, or to young seedlings. However, our studies are preliminary. It is hoped to develop this line of research with both fungi and bacteria, for all of the cushion gall types with which we are working.

In this connection, it may be mentioned that Ciferri, in Santo Domingo in 1929 (1), described and illustrated in cacao a gall of the type we now call greenpoint. He sent specimens to bacteriologists in the Bureau of Plant Industry, U. S. Department of Agriculture, in Washington, for examination. Studies of this material made by Nellie Brown and Florence Hedges, well-known specialists of that period in crown gall of plants, failed to reveal presence of Bacterium tumefaciens (Smith and Townsend), under which name the crown gall organism was originally described.

TRANSMISSION TESTS WITH FLOWERY GALL

Patch-bark graft inoculations

In June, 1958, patch-bark graft inoculations with flowery gall were made in 46 cacao seedling trees 2 years old, growing in a nursery row at Turrialba. The patches, mostly 2 inches long and 3/4 inch wide, each patch containing a normal-appearing bud, were taken from limbs of cacao trees severely affected by flowery gall. In June, 1960, two years later, the patches grafted on 42 of the nursery trees were still alive. Several of the trees had come into flower, but no transmission of flowery gall was evident under conditions of the test.

Pod-stalk inoculations with flowery gall

More than 126 pod stalks in 16 cacao trees propagated from cuttings of UF Clone No. 667 at Turrialba, were given tissue

nsplantations from flowery-gall cushions, in August, 1959 (4). method and place of inoculation were the same as those used for ue transplantation tests with greenpoint gall, described e. In May, 1960, nine months after the inoculations were per- ed, there was no development of flowery gall in the treated s, whereas similar inoculations employing greenpoint gall ue resulted in gall formation of the greenpoint type at 14 of inoculation points.

tact inoculations with flowery gall

In the same planting, and using the same methods as described e for contact inoculations with greenpoint gall, 65 normal er cushions on several trees were given contact inoculation flowery gall. No evidence of transmission was noted at 5 hs after the test was set up. However, as anticipated, it was rved that when the gall inoculum begins to dry out, insects ding in the flowery gall are apt to leave it and go to the un- ying normal cushion.

The test was repeated, using lighter wraps, a shorter exposure , and included observations of insect movements. Some of the very galls were applied direct to the normal cushions, others first placed in an insect-killing bottle of cyanide gas for minutes, and then applied to the normal cushion. Results of e tests are not sufficiently mature for a report at this time. ver, this method or a modification of it appears promising and prove of value as one of the tests to employ in transmission ies for all types of cushion gall. Contact inoculations based hese principles are now being made on a large scale for the ery gall type, at Turrialba.

h, gall-infusion, and bacterial-culture inoculations.

These types of inoculations with flowery gall were performed he same manner as described above for greenpoint gall. Thus they have given no evidence of transmission under the conditions oyed. However, these tests for flowery gall are not regarded as lusive. They should be repeated on a more extensive scale.

DISCUSSION

In attempts to transmit flowery gall, inoculations similar in od and in number of tests to those employed for greenpoint gall, tried. To date, none of these attempts have resulted in induc-

ing the flowery gall to develop in any of the test plants. There i
always the possibility of a long incubation period. Experimental
plants must be retained for a reasonable period to cover this poss
bility. We are now diversifying and enlarging our transmission tes
with flowery gall. These will include possible inter-relationships
between flowery and greenpoint galls, and as time permits, similar
investigations will be extended to include the other gall types.

A highly significant development in the problem of flowery-ga
control was the discovery of cacao clones that remain gall-free in
the presence of very heavy attack by the gall in susceptible clone
(3).

It is evident that variations in the pattern of transmissibil
ty may and do occur. These variations include such factors as age,
variety and condition of the host plant, the parts of the plant su
ceptible to gall development, the rate at which the induced galls
develop, their distribution and their survival on the host plant.
Some of these variations do not correspond precisely with the gree
point gall behavior as we see it in the cacao plantations.

It would appear that there may be causal components of green-
point gall, which alone do not induce the same effect as when all
are working together. For example, in transmission of greenpoint g
by means of transplanting gall tissue to pod stalks (4), the resul
ant, induced galls were typical of small greenpoint galls, but the
did not enlarge to produce the mature gall we see in nature. Did w
fail to transmit one or more of the components?

Possibly one of the supposed components such as a bacterium
might be transmitted by contact, whereas another component such as
a virus might require a graft or a specific insect for transmissio
An individual vector species conceivably might transmit one compo-
nent such as a bacterium, but not another component such as a viru
Or, it might transmit one virus or virus strain, or one bacterium
bacterial strain, and not another. More than one vector might be r
quired to transmit the complete greenpoint gall as we know it in n
ture. Possibly such factors play a part in the inter-relationships
between one gall type and another, particularly between the green-
point and the flowery gall types.

If the theory of causal components can be substantiated, thes
factors should be taken into account in developing and testing clo
resistance to the gall. They also should be considered in organiz
control through preventive or curative treatments.

SUMMARY

Experimental transmission of greenpoint gall was secured (1) 14 out of 143 transplantations of gall tissue on cacao pod lks, (2) in 3 out of 6 inoculations where detached galls were nd in contact with normal flower cushions, (3) in 3 out of 50 l-infusion inoculations of cacao beans, and (4) in 4 out of brush inoculations from galls to cacao half-beans. Thus far, refore, a total of 24 transmission tests with greenpoint gall e been successful in inducing the gall to develop in the in- lated plants. Up to the present, in our tests, inoculation of ao half-beans, or young seedlings, with bacterial isolates n greenpoint galls have not transmitted the disease. Our in- tigations of this phase of the problem, however, are only pre- inary, and in no way conclusive. Similar attempts to transmit very gall have been made, but to date no transmissions have n obtained.

RESUMEN

Transmisiones experimentales de agallas de puntos verdes se raron (1) en 14 de 143 transplantes de tejido de agallas sobre pedúnculos de las mazorcas del cacao; (2) en 3 de 6 inocula- nes donde las agallas separadas de otros árboles fueron colo- as en contacto con cojinetes florales normales; (3) en 3 de inoculaciones por infusión de agallas en almendras de cacao, y en 4 de 50 inoculaciones de agallas hechas con pincel sobre endras cortadas transversalmente por la mitad. Por lo tanto, la actualidad se han logrado con éxito un total de 24 ensayos transmisión con agallas de puntos verdes, habiéndose inducido llas en las plantas inoculadas. Hasta el momento, en nuestro ayos, no se ha logrado reproducir la enfermedad inoculando las endras cortadas por la mitad o las plantas jóvenes de semillas aislamientos bacterianos de la agalla de puntos verdes. Sin argo, la investigación que se está llevando a cabo sobre esta pa del problema, es todavía preliminar, y no puede considerarse ninguna manera concluyente.

En los ensayos para transmitir la agalla floral se utilizaron mismos métodos y el mismo número de inoculaciones que en el o de la agalla de puntos verdes. Hasta el momento no ha sido ible reproducir la agalla floral en ninguna de las plantas de erimentación.

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AN ATTEMPT TO TRANSMIT CUSHION GALL OF CACAO BY BUD GRAFTING AND THE EFFECT OF MALATHION ON GALL DEVELOPMENT.

L. R. Siller*

INTRODUCTION

In the early stages of our investigations on Cushion Gall of o, an attempt was made to transmit the disease by budding healtrees with budwood taken from diseased trees, and to study the ct of Malathion on gall development. This insecticide was en owing to the wide range of insects and mites against which it ffective. The experiment was performed in a plot in which Cun Gall was just beginning to appear, it was hoped thereby to obe any increase in the incidence of galls consequent upon bud ting, and any decrease or inhibition of the disease as a result ne insecticide treatments. The results have been somewhat unexed and are therefore reported now.

MATERIAL AND METHODS

The experiment is being carried out at La Lola, the cacao expeital farm of the Inter-American Cacao Center in Costa Rica. It egun in January, 1958 and consists of 149 trees, all of which ooted cuttings, mainly of clones UF 613 or UF 221 planted at 10 feet and between 4 and 6 years old. All receive a monthly of 4-4-50 Bordeaux Mixture.

Four experimental treatments are applied

Check. No treatment

Bud-grafted. Eight old trees severely affected by Cushion Gall were selected elsewhere in the farm. Apparently healthy buds were taken from these trees and four patch-budded in various positions on each of the trees in this treatment. (Previous attempts to graft diseased buds were unsuccessful).

Insecticide. Each tree is thoroughly sprayed with Malathion every 21 days, with particular attention to the trunk and branches. Each gallon of spray contains 10 ml. of Malathion with 50% active ingredient.

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istant Pathologist, Inter-American Cacao Center, Interrican Institute of Agricultural Sciences, Turrialba, Costa Rica.

4. Bud-grafted and insecticide. Treatments (2) and (3) combined.

Differently treated plots are separated by guard rows.

Data on gall development are taken every 14 days from each tree, classifying the galls according to their stage of development; position on the tree, and type, and noting the development of a flow er cushion subsequent to the disappearance of a gall.

RESULTS

A summary of some of the data obtained from the original trees is presented in Table I. Table II shows the development of galls on the new growth originating from the grafts made with buds taken from galled trees.

Table I. Numbers of galls developed in the original trees between January, 1958 and December, 1959

Treatment	Number of trees	In January 1958	
		No. of trees infected	No. of galls
Check	50	9	28
Bud-grafted	35	10	25
Insecticide	33	7	54
Bud-grafted and Insecticide	31	5	13
Totals	149	31	120

Treatment	Between January 1958 and December 1959						
	No. of trees infected	(A)	(B)	(C)	(D)	(E)	Totals
Check	50	1586	128	29	383	94	2220
Bud-grafted	34	1371	94	21	266	61	1812
Insecticide	33	837	171	33	377	84	1502
Bud-grafted & Insecticide	31	431	82	8	110	17	648
Totals	148	4225	475	91	1136	256	6183

Galls alive in December 1959

Galls which began to develop but died without maturing; cushions without flowers by December 1959

As (B); cushions flowering in December 1959

Galls which matured but later died; cushions without flowers in December 1959

As (D); cushions flowering in December 1959

le II. Numbers of galls developed in the new growth from buds taken from galled trees

Treatment	No. of trees	Number of trees with galls on the new bud-growth	No. of galls on the new bud-growth	
			Green-point	Flowery
l-grafted	35	19	63	1
l-grafted & ecticide	31	6	0	8

DISCUSSION

The tremendous increase in the incidence of Cushion Gall in area during the two years is apparent. Budding with bud-wood infected trees has had little effect on the amount of infec-, but any transmission that might have occurred has been masked he natural increase in incidence. The insecticide treatment, st not controlling the Cushion Gall on the original trees, ap-s to have had a marked effect in reducing the incidence of gall he new growth from the buds.

A possible hypothesis to explain these results is that the s were originally infected with Cushion Gall, but that the in-ive principle did not move into the new budgrowths. New infec- may have been largely kept from the new budgrowths by the cticide treatment.

A remarkable fact is that of the 64 galls developed on the growths in the absence of insecticides, 63 were green-point s, and only one was a flowery gall. The 8 galls developed on bud-growths on insecticide-treated trees were all flowery galls.

Unfortunately records of the type of gall present on the trees from which the buds were taken were not taken at the time the buds were obtained, but all the trees now have both types of gall. Of the 6,183 galls which developed on the original trees, about 5 percent were green-point galls, and the remainder were flowery galls.

Not one pod has yet developed on the cushions carrying gall, even on those on which galls developed and subsequently died. There have been many cases of galls which have developed on a cushion subsequent to fruit set. A rather small percentage of the flower cushions which carried galls which died during the two-year period were flowering by December 1959.

A marked periodicity in the development of galls according to the time of year was noticed. This aspect and other data obtained from the experiment are currently under study.

SUMMARY

Two groups of 4 - 6 year-old clonal cuttings were bud-grafted with material from Cushion Gall infected trees. One of these groups was treated every 21 days with Malathion, while the other one remained unsprayed. A third groupd received no buds but was sprayed with the insecticide while a fourth group served as check. Natural spread of Cushion Gall in the area of the experiment masked possible differences of gall numbers in the cuttings. The insecticide treatment had a marked effect in reducing the number of Cushion Galls on the new growth from the buds. Mainly green-point galls developed on the untreated bud-wood growth. A hypothesis to explain these data is given.

RESUMEN

Dos grupos de estacas clonales de 4-6 años de edad fueron injertados con yemas de árboles infectados con Agalla del Cojinete. Uno de los dos grupos recibió un tratamiento de Malathion cada 21 días, en tanto que el otro no fué fumigado. Un tercer grupo no fué injertado, pero sí fué fumigado con el insecticida; el cuarto grupo sirvió de control. La propagación natural de la Agalla del Cojinete disfrazó las diferencias que hubieran podido existir en el número de agallas de cada estaca. El tratamiento con insecticida tuvo un efecto marcado al reducir el número de Agallas del Cojinete en los nuevos brotes de las yemas. En general,la agalla de puntos verdes fundió en los brotes de las vareta no tratadas. Se ofrece una hipótesis para explicar esta información.

A NOTE ON THE RELATIONSHIPS BETWEEN FLOWERY CUSHION GALL, SELF-INCOMPATIBILITY AND FLOWER DEVELOPMENT

Jorge Soria*

SELF-INCOMPATIBILITY AND FLOWERY CUSHION GALL

There has been some confusion between the early symptoms of wery gall and the appearance of self-incompatible trees. Few s develop from cushions showing flowery gall. The morphological tures of flowery galls were compared with those of the cushions self-incompatible trees, and it was found that the former could readily distinguished by a pronounced swelling on the flower hions.

In order to determine whether flowery gall causes either the len or the ovary to become inviable, the following controlled linations (between 30 and 40 in each case) were made:

a) Pollen from a flowery gall on flowers of a flowery gall

b) Pollen from a flowery gall on normal flowers

c) Pollen from normal flowers on flowers of a flowery gall

d) Self-pollinations of flowers on flowery galls

e) Check: observation of unpollinated flowery galls

Normal fruit-set was obtained from all the cross-pollinations, licating that both the pollen and ovules were normally functional. fruits matured normally and gave viable seed which germinated gave normal seedlings.

In addition, pollen from the flowers of flowery galls germina- normally on artificial media. No fruits set on the check flo- in treatment (e).

Trees known to be self-incompatible and with abundant flowering, without the characteristic swelling of the cushions, were self- inated at the same time and produced no fruits after more than self-pollinations.

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neticist, Inter-American Cacao Center, Inter-American Institute Agricultural Sciences, Turrialba, Costa Rica.

It seems that some factor other than pollen or ovule abnormality must be responsible for the apparent failure of flowery galls to set fruit.

INFLUENCE OF FLOWERY GALLS ON FLOWER DEVELOPMENT

The flowers which abscissed from two flowery galls over a period of 128 days were collected and classified according to whether they dropped at an incipient stage of development, when partly developed, or when normally mature. The results are shown in the following table.

Numbers of flowers dropped at three stages of development from two flowery galls in 128 days

Gall No.	Incipient	Partly developed	Normal	Totals
1	120	124	202	446
2	70	67	251	388
Totals	190	191	453	834

The "independent distribution" test showed highly significant differences between the stages of abscission. The very large number of flowers produced is noteworthy; over half of them reached maturity. Flowery gall does not seem to interfere with normal flower development.

SUMMARY

Fruit rarely develops on flowery galls. A series of hand pollinations was made using flowers from galls to see whether the galls affect the development or functions of the pollen or the ovu In all cases a high percentage of fruit-set was obtained; the fr developed normally and the seed germinated normally. Flowery gall does not affect the gametes, but apparently causes failure to poll nate. The majority of the flowers on galls also apparently develo normally.

RESUMEN

A causa de observaciones hechas de que la fecundación de las
es en agallas del tipo floral es muy rara, se hizo una serie
olinizaciones con flores en agallas para determinar si esta
rmedad afectaba el desarrollo y funcionamiento del polen y
óvulo. En todos los casos de obtuvo alto porcentaje de cuaja-
to de frutos; éstos desarrollaron hasta su madurez y sus semi-
germinaron normalmente. La agalla del tipo floral no afecta
iología de los gametos del cacao, únicamente ocasiona falta de
nización. Las agallas no afectaron tampoco el desarrollo de
ran mayoría de las flores.

CUSHION GALL OF COCOA IN TRINIDAD

L. Goberdhan and D. Ganpat[*]

REVIEW OF THE LITERATURE

Hosts

Plants affected - Cushion Gall occurs primarily as a disease of the cocoa plant (Theobroma sp.). A similar hyperplasia of mango (Mangifera indica) has been mentioned by Losada (6). Gall-like formations have been found to be present on Mango (Mangifera sp.) and wild pois doux (Inga Sp.) in Trinidad.

Varietal susceptibility - Hutchins et. al. have reported varietal susceptibility to "flowery Cushion Gall" of cacao (3). The following clones have been classified as gall free: UF-29, UF-242 and UF-273. UF clones 122, 168, 191, 210, 342, 601, 606, 10-A, 10-1A, BE-37, ESP-36, LY, V-47 are suggested to be highly susceptible.

The majority of cocoa varieties on commercial plantings on the island display this condition. Surveys to determine presence or absence of galls on four clonal types were conducted at La Reunion. Clone UF-168 was found to have galls present. Clone UF-168 has also been reported by Hutchins of Turrialba to be highly susceptible (3). Table 10 shows a complete list of clones suffering from this malady; some of which may exhibit varietal susceptibility. SCA. 6 has not yet been found to occur with this condition.

Nomenclature

The disease is generally known as Cushion Gall although it has been referred to as "Buba". Garces in Colombia called it "Verruga del Cojin Floral" (1). In Surinam it has been referred to as "Yaw". The disease is referred to in Trinidad as Cushion Gall.

Range of Occurrence

In Colombia twenty years ago this condition was first reported by C. O. Garces, plant pathologist, at the University of Medellin (1). In 1951 it was recorded in Nicaragua by A. G. Kevorkian (8) and again in 1954 by Wellman and Orellana. In 1951 it was also observed

[*]Ministry of Agriculture, Trinidad & Tobago.

occur in Costa Rica and Panama, and in 1955 in Surinam. Orellana orts the condition as occurring in Ceylon in 1958. In the same it was officially reported from British Guiana. In 1959 it was orded in Ghana and Nigeria.

The condition occurs in all cocoa growing areas of the island Trinidad.

nomic Importance

Nature of losses. The most evident and probably the most se- s losses from the disease are those due to reduction of number nature pods. Very few diseased cushions will set fruit and bear ure pods (1). As this condition worsens on a tree, that is, when or most cushions are affected by gall formation, the tree pro- ssively becomes less productive.

ant of Losses

Kevorkian estimated that 25 per cent of the cocoa trees in tern Nicaragua were affected by Cushion Gall. In a few planta- s he found from 50-75 per cent of trees affected (1). Hutchins orts that in one planting which is now heavily infected less than per cent of the galled cushions bore any fruit. Ghana and nam report the condition as of little economic importance.

At present galls are of little economic importance here in idad. Knowing the seriousness of the condition in south-west ragua, serious attention is being paid to this condition.

otomatology

The characteristic symptom is the gall found on trunks and bran- .

Morphologic symptoms - The following descriptions are after hins (1, 3).

Flowery type galls - Flowery galls bear a great number of ely packed flowers, which develop fully, but of which very few be pollinated naturally. After a time the flowers die. The ened mass of dead flowers clings to the gall for a considerable od, but eventually gives way to new floration which will result repeated development of masses of fresh flowers on the same gall.

Green point type gall - The galls are usually dark brown, more ess hemispherical, and cauliflower-like in appearance and texture. are first noticeable when about 1/3 inch in diameter but develop

rapidly. Within a growing season they may attain a diameter of 1 to 3 inches and a thickness of an inch or more. A few cushions 4 to 6 inches in diameter and 3 to 4 inches thick have been seen. Upon becoming affected, the floral cushion is stimulated to produc a large number of floral initials, or buds, none or only a few of which may open; this produces a profusion of bright green points on the corrugated, brown surface of the gall when it is in a live, growing condition.

The morphology of all galls found in Trinidad agrees with the description given for the green point type of gall by Hutchins (1) No galls of the flowery type have been observed on our cocoa. Flo wery type cushions found here have been referred to as "Star Broom and have been attributed to the Witches' Broom fungus Marasmius perniciosus. Hard round knob-like galls have been found to occur on some trees. This type of gall seems to be the result of pruni wounds developing into abnormal callus formation.

No visible symptoms have been observed on leaves.

Histologic symptoms - No work has been reported in this aspect

Etiology

The cause of Cushion Gall is still unknown. The etiology of gall formation remains obscure.

Epidemiology

Environmental factors may be of some importance in the spread of the disease, but little is known at the present time.

Control

It has been suggested that clonal material (cuttings) should taken from trees - particularly from gall-free areas, apparently affected by galls.

REPORT ON CUSHION GALL IN TRINIDAD

In 1958 Lee M. Hutchins of the Cocoa Center, I.A.I.A.S., Turrialba, Costa Rica, made a survey in collaboration with Cocoa Board to determine the incidence of Cushion Gall in Trinidad. A condition closely resembling Cushion Gall of Central America does occur here. This condition has been observed previously and has been present for many years on our cocoa.

veys

Surveys were carried out on ten locations in the island. ese surveys were conducted on trials laid down by the Cocoa rd. Each trial contained fifty different clones:-

e Trials -

Estate	Location	Soil Type	Year Planted
Poole Syndicate	Rio Claro	Princes Town Heavy Clay	1952
El Rosario	"	Talparo Clay	1952
Santa Severa	Brasso	Brasso Clay	1952
El Toco	Toco	Calcareous Schist	1952
Arethuse	Sangre Grande	Moruga Loam	1952
San Francisco	Mitan	Brasso Clay	1952
River Estate	Diego Martin	Northern Range Alluvial	1952
San Jose	Gran Couva	Montserrat Clay	1953

The other two locations surveyed
9. La Reunion 10. Marper.

hod of Survey

Surveys were made during each quarter in the year by a team of cially trained men.

Trees on the ten locations were examined individually from top bottom for the presence of galls. Each tree on these trials is exed. Records of number and type affected with galls were main- ned.

Table 1 shows details of tree infections on the eight trials.

Table 1 List of clones affected with galls at different farms

No.of clone	Total no.of trees	Percentage of trees affected in each Estate								Percentage of total no. of trees affected
		Poole Synd.	El Rosario	Santa Severa	El Toco	Arethuse	San F'cisco	River	San José	
ICS 1	1720	10	6.6	4		5	6.6	14	5	7.6
" 6	220	10	3.3	3.3			3.3			2.7
" 8	220	6.6					6.6	26		5.4
" 9	170		15		5		5		5	3.5
" 16	70							10		4.3
" 22	150		10				10			2.7
" 32	220	23.3	10				13.3	16.6	10	9.5
" 35	70	5			10			53		27
" 37	170	30	10			5	5	3.3	10	7.7
" 38	170	10	5				5		5	3
" 39	220	6.6	23.3	6.6		5	15	33.3		11.3
" 40	220	20	10	3.3				16.6	5	7
" 43	220	10	3.3	6.6	3.3	5	16.6	13.3	5	8
" 44	50							16.6		10
" 45	170	10					5	6.6		3
" 46	220	40	26.6	43.3	3	5	40	56.6	25	32
" 47	220	46	30	30	6.6	15	63	46.6	40	35
" 48	220	20	16.6	6.6			20	30	25	16
" 49	70	25						53.3		30
" 53	70	10			5			16.6		11.5
" 60	220	3.3	16.6	3.3		5	23	43.3	10	14
" 61	220	16.6	13.3	13.3	6.6		23	16.6	25	15
" 70	130	5	10					6.6		4
" 73	100	5				5				2
" 75	220	16.6	10	10		5		3.3		5.5

No.of clone	Total no.of trees	Percentage of trees affected in each Estate								Percentage of total no. of trees affected
		Poole Synd.	El Rosario	Santa Severa	El Toco	Arethuse	San F'cisco	River	San José	
ICS 79	220		6.6	3.3			26.6	13.3	5	7.5
" 84	220	3.3		6.6		10	13.3	3.3		4.5
" 85	170		5					6.6		1.8
" 87	170		5				5	26.6		7.5
" 89	220	20	13.3				16.6	50	5	14
" 91	120						10			2.5
" 94	30									35
" 95	1670	6	12	5	3.3	5	36.6	9.5	15	7
" 98	220	10		3.3	6.6			6.6	30	6.5
" 100	220		5		10		10	20		6
PA 121	140								10	1.4
" 150	140	20			5					4
" 39	80		5							1.25
" 46	140								5	1
SP 1	50	10						3.3		6
P 7	60	5								1.6
P 18	170		5					3.3		1.2
P 30	150							13.3		2.7
P 32	20								5	5
DS 1	20								5	5
E 660	70								5	1.4
GS 29	50							6.6	20	12
" 36	50							16.6	5	12
IMC 57	130		5					6.6		2.5
" 67	220		6.6					3.3	20	3

At Marper Farm two blocks of seedling crosses were surveyed seven times. Table 2 and Figure 1 show the increase in trees affected.

Table 2. Increase in trees affected with galls.

Block No.	Total No. of trees	Trees affected in seven surveys						
		1958	Sept. 1958	Dec. 1958	March 1959	June 1959	Sept. 1959	Dec. 195
5 M	1005	62	82	86	124	149	160	177
6 M	1330	54	117	121	153	180	224	235

Clones of the types UF; ICS; PA; GS; TSH were surveyed at La Reunion for presence or absence of galls with the results shown below:

	Galls were present in	Galls were not present in
UF	168, 654, 668	221,613,650,667,677
PA	30, 150	13,29,37,46,56,81,121,160, 169,191,218,288
GS	29, 30, 36, 65	4,5,19,32,48
TSH	600, 687	532,543,565,578,644,667
ICS	1,40,47,53,75,84,89,95, 98,100	

Table 1 suggests that some of our clones may exhibit varietal susceptibility towards greenpoint type gall formation.

Epidemiology

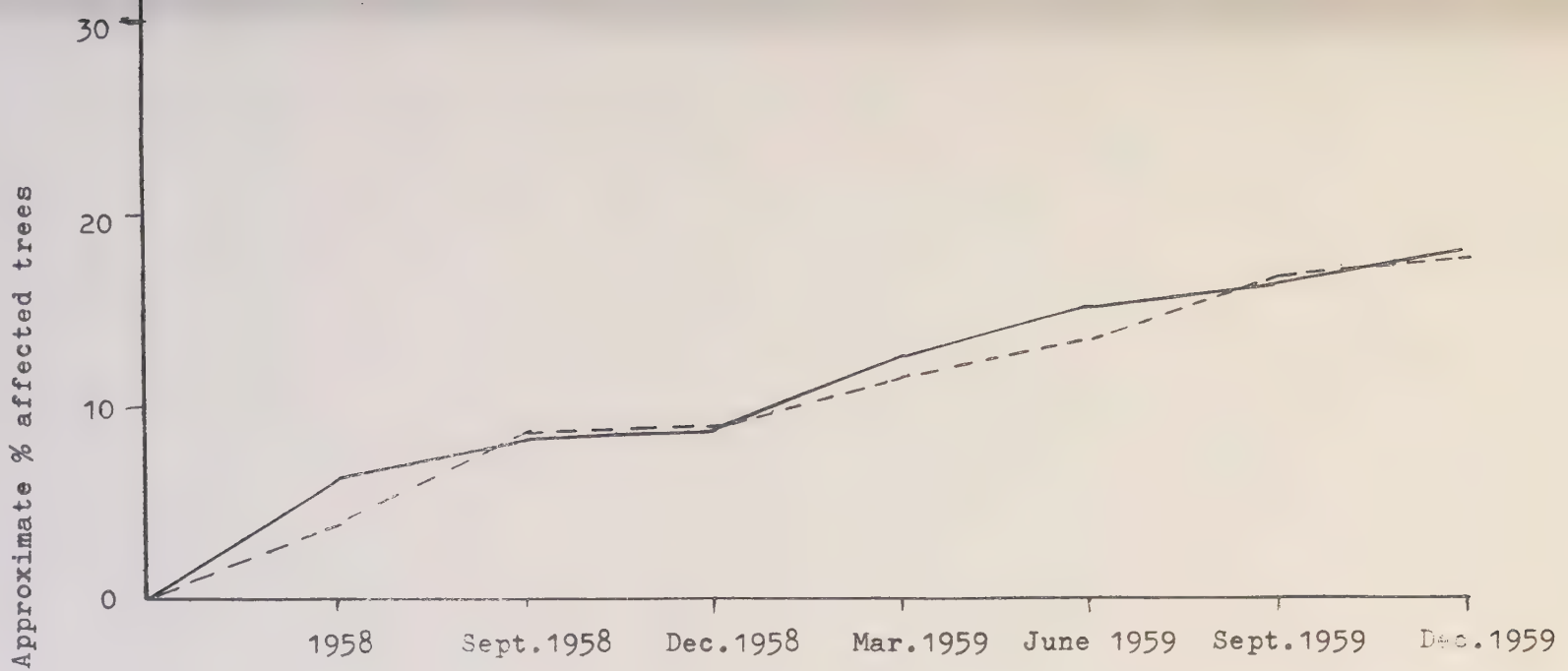
Little is known of the importance of environmental factors in the spread of the disease. The following observations suggest that spread is favoured by cool, moist conditions.

1. Observations suggest that more galls are produced during wet weather. The presence of a large number of flower cushions during the wet period may be responsible for this occurrence.

2. During dry weather galls dry up quickly and disintegrate. Trees which were previously affected by this condition in the wet season seem to be free from this disease during the dry. This was particularly noticeable in 1959 when we had a marked dry season which lasted longer than usual.

3. Clones under shade show a greater number of galls than clones without shade. Galls produced on trees growing in shade were greener and larger.

4. Trees on flat areas showed presence of a greater number of galls, while those on tops of hills displayed fewer and smaller galls.



BLOCK 5M ——————

BLOCK 6M - - - - -

Total No. of trees surveyed

BLOCK 5M 926

BLOCK 6M 1352

FIGURE 1 - Percentage increase in trees affected - BLOCKS 5M & 6M

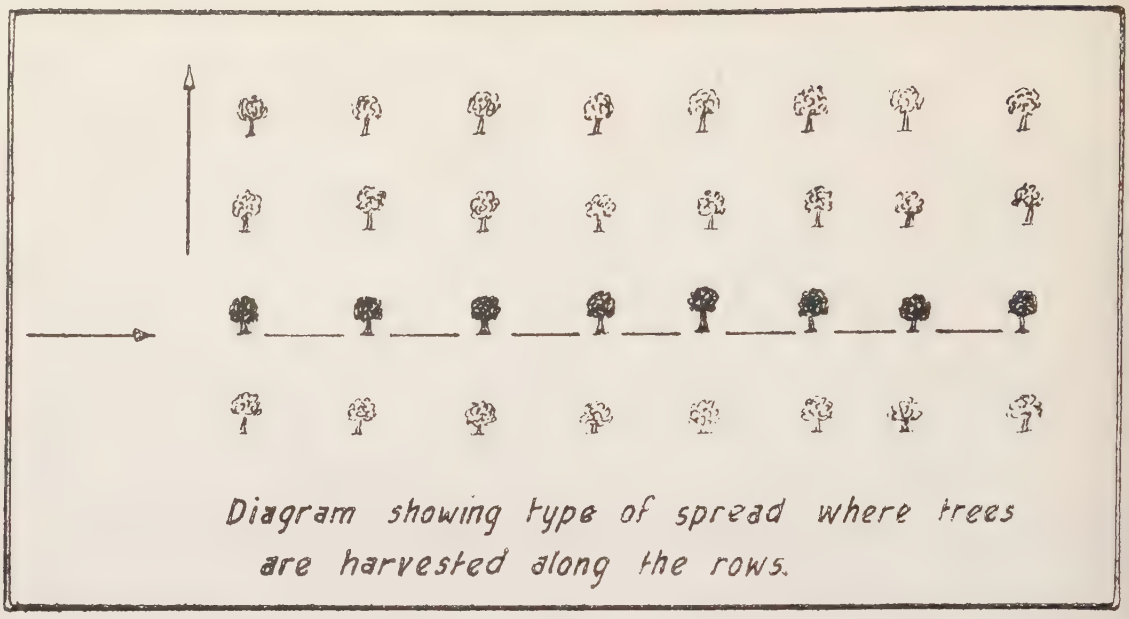


Diagram showing type of spread where trees are harvested along the rows.

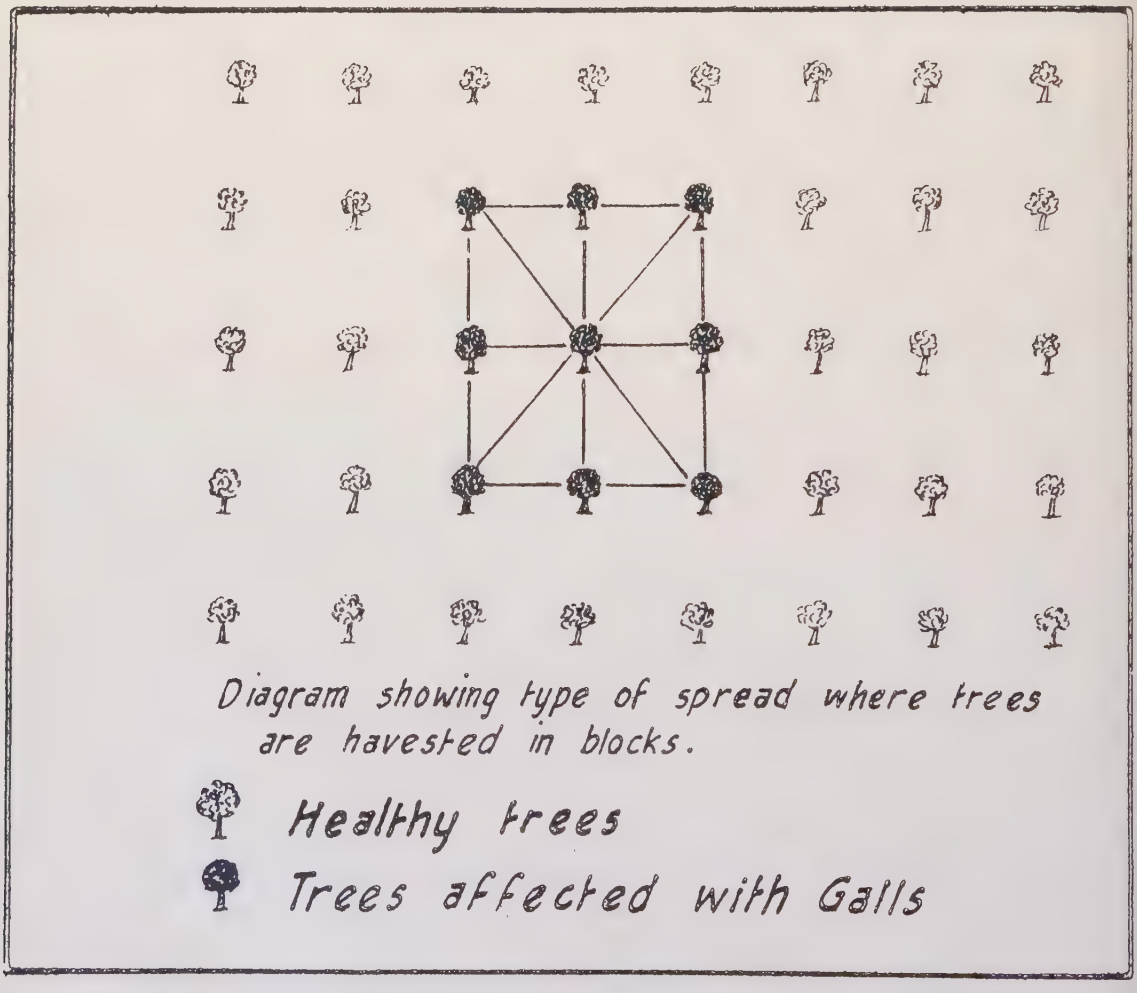


Diagram showing type of spread where trees are havested in blocks.

Healthy trees

Trees affected with Galls

Fig. 2 Showing possible patterns of spread

Under cool moist conditions flower cushion production increases. There may therefore be some relationship between number of galls present and quantity of flower cushions produced.

of trees affected

Trees under the age of three years do not show any symptoms all infection. Trees do not come into flower cushion produc- until they are about three years old and this is probably why alls are found on young trees. An ICS-89 clone at La Reunion, ars old, was the youngest plant found to have any gall present.

of Spread

The following table and Figure 1 show that the condition is ading.

e 3. Percentage increase in trees affected

ck No.	Approx. % affected	Sept. 1958	Dec. 1958	March 1959	June 1959	Sept. 1959	Dec. 1959
5 M	6.3	8.3	8.7	12.7	15.2	16.3	18
6 M	4	8.7	9.0	11.5	13.5	16.8	17.7

the table the rate of spread is quite similar in both blocks each quarter of the year. Flower cushion production in both caseem to be alike, and this may be a limiting factor in absence resence of galls.

ern of Spread

Pods were harvested according to two patterns: along the rows; in blocks. The pattern of disease incidence indicates that ad may occur in the harvesting pattern. Figure 2 shows the two retically possible types of spread and suggests that spread or smission of the condition may occur by harvesting implements.

hes' Broom and Green Point Gall Formation

Some trees affected with Witches' Broom (Marasmius perniciosus) also been found to have galls present. These galls appear to inate at the base of the broom and may suggest infection of young initial.

Chupon terminal infection occurred in Ghana (7) and this may lead one to believe that the apical meristematic tissue was the on attacked.

It would seem that only meristematic tissue is affected by this ition.

etermination of Cause of Cushion Gall

Transmission tests

(a) Cuttings from the following clones were taken from infected trees at La Reunion:

ICS	1	NG	3	GS	18	TSA	464	TSH	641	PA	30	IMC	67
"	36	"	10	"	19	"	644			"	150		
"	39			"	29								
"	40			"	30								
"	47			"	32								
"	49			"	36								
"	53			"	89								
"	61												
"	84												
"	95												
"	100												

These plants have shown no visible signs of the disease and will be put out into an isolated field this year for further observation.

) Seedlings from seed pod which was produced from diseased cushions. These have also shown no visible signs of the condition and will be transplanted in an isolated field f further observation.

(c) Grafts of clonal material from infected to non-infected trees. We have been able finally to get patches of cocoa tissues affected with galls to grow on to young healthy clones. 63% of such patch-buds have caught. No transmission of the disease has been observed. Galls on the patches in some cases have continued to grow. These trees will also be placed into isolated fields and further observations will be made.

It must be mentioned that all trees at the present time are no in the stage of flower cushion production, and this may explain the noticeable absence of galls.

In cases (refer (c) above) where galls were grafted on, observations were made: (1) Galls have continued to grow and (2) In some cases floral initials are appearing. This confirms that the condition does occur on flower cushions. At points where galls have dessicated and disintegrated, normal flower cushions are being produced. This behavior suggests that trees could return to normal flower cushion production.

We have made no attempt as yet to isolate any possible pathogen.

SUMMARY

A short review of the literature was made relative to the condi-
in Trinidad. Cushion Gall is found on a large number of clones
occurs in all cocoa growing areas of the island. Only green-
t type gall has been observed in Trinidad.

Spread or transmission of the condition can be made possible by
ing implements.

Moist conditions favour and increase gall production. Only
g growing tissue seems to be affected.

RESUMEN

El autor presenta una revisión corta de la literatura sobre la
en Trinidad. La enfermedad se encuentra en muchos clones di-
ntes y en todas las zonas cacaoteras de la isla. Solamente se
observado agallas del tipo punto verde.

Parece posible que la enfermedad se extienda por medio de los
amientos de cosecha.

Condiciones ambientales húmedas favorecen el desarrollo de la
rmedad. Aparentemente afecta sólo los tejidos jóvenes en cre-
ento activo.

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CUSHION GALL TYPES IN CACAO

Lee M. Hutchins * and Luis R. Siller **

INTRODUCTION

t least five types of galls or outgrowths have been recogniz- the flower cushions of cacao. These types are distinctly dif- t one from another and each type may have variant forms with- own group. The purpose of the present paper is to describe llustrate these five gall types.

ushion Gall in one or another form is now known in most if not the cacao-growing countries throughout the Western Hemisphere. been reported also from Africa and Asia. Uniformity in the names of the different galls, where practicable, would avoid onfusion in correspondence and reports, and in discussions of oblem. Some progress has been made in selecting appropriate for the respective gall types. The old and the new names are t together here for consideration by pathologists and others e concerned with research into Cushion Gall and its control. onal gall types no doubt will be described as research prog- in the several countries where the disease occurs.

RECOGNIZED TYPES OF CUSHION GALL

English name	Spanish name
Green point gall	Agalla de puntos verdes
Flowery gall	Agalla floral
Knob gall	Agalla en forma de perilla
Disc gall	Agalla en forma de disco
Fan gall	Agalla de abanico

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lant Pathologist, American Cocoa Research Institute, Washing- on, D.C. Address: Inter-American Cacao Center, Inter-American nstitute of Agricultural Sciences, Turrialba, Costa Rica

ssistant Plant Pathologist, Inter-American Cacao Center, Inter- merican Institute of Agricultural Sciences, Turrialba, Costa ica

In assembling the gall descriptions that follow, some materi is taken from our earlier publications, notably from the appendix Report No. 31 (1959) by Hutchins (5), where English names for sev al gall types were originally proposed and descriptions given.

Cushion Gall sometimes goes under the name Buba, which is a ical term meaning "soft tumor". This term as applied to Cushion appears in a paper by Wellman and Orellana, in 1954 (14), under t title, "Buba or Cushion Gall of Cacao in Nicaragua". Their paper describes and illustrates the type of outgrowth that we now are c ing "greenpoint gall". But the term Buba applies equally well to the recently described "flowery gall" (5). It does not apply to last three types of the above list. Therefore, in view of the ne gall types recently included in the Cushion-Gall complex of sympt the more definitive and more inclusive term, Cushion Gall, would pear preferable to the term Buba, which is not inclusive and does not indicate the part of the plant that is affected.

The term Cushion Gall thus becomes a nonspecific designation for all of the gall-like outgrowths from the flower cushions of c cao, but in itself does not indicate type or cause. This usage comparable to such inclusive terms as "blight" and "wilt", in wh the character of disorder is implied, but which may be due to an several causes. When using the term Cushion Gall, therefore, we should refer to the type of gall that is meant, where type is im tant.

Symptoms of one or another type of Cushion Gall at times ma pear in parts of the tree other than the flower cushions. In so of these instances, the gall has been observed to develop in the inity of an axillary bud.

GREENPOINT GALL

History

The term greenpoint gall was introduced by Hutchins in 1959 and is synonymous with other designations for this disorder which were used under various names in earlier descriptions. Examples Agallas leñosas, by Ciferri in 1929 (1); Verruga del cojin floral Garces in 1940 (3); Cushion Gall disease, by Kevorkian in 1951 (Buba or Cushion Gall, by Wellman and Orellana in 1954 (14); Yaws, Van Suchtelen in 1955 (15); La Buba o agallas del cacao, by Mala in 1958 (9); Cushion Gall, by Hutchins in 1958 (4); and Cushion by Orellana in 1959 (11).

In our paper, Current Surveys for Cushion Gall (4), presented
958, it was stated, "Perhaps the first published account of the
ase was by Garcés (3), in 1940". A still earlier paper, the one by
rri (1), now has come to our attention. The gall which he brief
escribed and illustrated under the name agallas leñosas resem-
Greenpoint Gall as we know it today. It would appear, there-
, that this may be the first published account of the greenpoint
of Cushion Gall in the Western Hemisphere.

In a private communication from A. A. Brunt and A. L. Wharton,
he West African Cocoa Research Institute, Tafo, Ghana, in Janu-
1960, it is stated: "Early records, Dade 1926 (2), showed that
s identical in appearance with those described as 'greenpoint'
utchins had been known on cacao in Ghana since 1923".

In an illustrated paper published in January 1959 (11), Orell-
reported typical Cushion Gall of the type we now call greenpoint,
rring in a very limited area of Ceylon.

Thus we see that greenpoint gall, or something closely resem-
g it has been known in the Americas since 1929; in Ghana since
; and in Ceylon for an undetermined period, probably not less
5 years.

toms

With the onset of greenpoint gall in a flower cushion, a few
n, bud-like points begin to form and their number soon increases.
in several weeks, the gall may grow to one-half inch both in dia-
r and elevation. One of the galls under observation increased 3
es in diameter and 3 inches in height within 12 months. Occa-
lly a gall may attain a diameter of 4 to 6 inches.

The colour of the young galls is bright green. The older, liv-
galls assume a base colour of dark brown, on which is displayed
eat number of abortive, bud-like growths which remain as fresh
n points distributed in profusion over the corrugated brown sur-
of the gall. It is rare for these greenpoints to develop fur-
, and the greenpoint gall except when very young is almost al-
devoid of flowers. (Fig. 1).

Greenpoint galls usually are globose and semi-hard. Unless
ed about the stub of a small branch or pod, many of them are
ly broken off from the trunk or limb on which they have develop-
When severed from the tree in this way, it will be noted that
swollen, fleshy part of the gall is superficial and is borne on
ort central stalk, perhaps one-fourth to one-half inch in dia-
r, which is the only firm attachment between the gall and the

supporting trunk or limb. In some instances, the gall has a bro
er base and no well-defined central stalk.

The fresh inner tissues of the enlarging gall are light cold
ed, somewhat soft in texture, branch out both laterally and verti
ally from the central stalk. In such cases, the broad, lower sur
face of the gall is flattened against the bark of the trunk or li
on which it is borne, where it merely rests against the bark with
being attached to it by any growth union other than the central s
porting stalk.

As the gall ages, portions of it may die, and the green poin
on such parts will disappear. Finally, the entire gall will die.
It then usually becomes black, carbonous in structure, and is eas
shattered.

As seen in bearing trees, symptoms of greenpoint gall develo
for the most part only in the flower cushions. Even in trees mos
heavily attacked, identifiable symptoms have not been discovered
the leaves nor in the fruits with the exception of an occasional
gall on a pod stalk near its point of emergence from the flower
shion. From time to time may be seen a typical Greenpoint Gall
veloping on non-flowering sucker growth, but this is not the rul
In such cases there is the question of whether the gall may be d-
veloping at the site of an adventitious bud.

Malaguti (9), in Venezuela, reports exceedingly interesting
extensive gall formations of the greenpoint type occurring in tre
2 to 3 years old, and also on 3-month-old seedlings. In the lat
case, the galls developed on the stem, either in the zone of atta
ment of the cotyledon to the stem, or in the axle of a leaf with
stem.

Importance

Details of distribution and importance of greenpoint gall ar
discussed in publications cited under History, above. Briefly, t
greenpoint type is known to be sparsely distributed over a wide a
in the Americas. Epidemic outbreak has been reported in parts of
Nicaragua, Costa Rica, and Colombia.

FLOWERY GALL

The term flowery gall also was introduced in 1959 (5). Flowery
generally are globose and of various sizes up to 2 or 3 inches
ameter. They seldom attain the large size of old greenpoint
, which latter are known to reach a diameter of at least 6 in-
in extreme cases. Their most characteristic feature is the
number of normal-appearing flowers borne by these galls over
entire periphery (Fig. 2). In seasons of floration one gall
ear hundreds of flowers. As mature flowers die and fall, the
ing crop of buds continues to produce a new crop of flowers.
may go on for several weeks at a time, or through a whole
n of floration.

In an advanced case, nearly all of the flower cushions on the
, arms, limbs, and well out on the smaller branches will show
extreme type of floration. Towards the end of the flowering
d, mats of dead and fallen flowers sometimes may be seen on the
d, out for a distance of a foot or more from the trunk.

Very few of the flowers borne on flowery galls will be success-
pollinated by natural means, but Soria has shown that normal-
ring pods may develop from such flowers by hand pollination (13)

The internal structure of flowery gall is very similar to that
e greenpoint gall. Many of the galls are borne on a stalk and
asily broken off from the limb. Semi-hard ligneous tissues
the stalk, which connects directly with the wood of the sup-
ng limb. The upper portion of the central stalk branches lat-
y. Over the stalk core and its branches is formed a layer of
chymatous tissue through which the flower initials emerge. A
in percentage of flowery galls, as in the case of greenpoint
will be more or less flat along the limb, and not formed on a
.

Until the flowery type was understood and classified as belong-
the symptom complex of Cushion Gall disease, it was confused
he phenomenon of multifloral cushions often referred to as in-
ng a "male" tree, and thought to be associated with self-incom-
lity (10, 12). Except perhaps in early stages of development
wery gall, there is no question about its identification. In
tance will the self-incompatible or "male" tree develop a gall
flower cushion in any way resembling a well-developed case of
y gall, unless by chance the incompatible tree actually has
cted the disease.

Flowery gall can spread rapidly in a planting, sometimes more rapidly among cuttings of a clone than among seedlings of the same clone. Among cacao clones, marked differences in varietal susceptibility to flowery gall have been reported (6).

KNOB GALL

Knob galls are hard, woody, smooth-surfaced swelling up to an inch or more in diameter, which may occur in the flower cushion, but which bear no flowers. (Fig. 3). They are widely distributed, but are relatively unimportant. An affected tree seldom shows more than 10 to 15 galls, usually less over its entire fruiting area. Often no knob galls at all may be seen in a whole planting, or they may be seen only in a few scattered trees (5).

DISC GALL

(Formerly called "hard flat gall")

The name "hard flat gall" was first proposed by Hutchins (5) to describe a gall of the flower cushion seen in the course of surveys in Ecuador and Brazil, in 1958. He recorded the same disorder during a survey trip in Guatemala in April, 1959 (Fig. 4). The following description is taken from page 4 of a report of the latter trip (7).

> "At another location...., we inspected a planting consisting of 60 acres of seedlings of the Nicaragua type, supposedly grown from seed locally secured in Guatemala. The trees were more than 35 years old, were planted 15 feet apart on the square, and were well pruned. It was a beautiful planting.
>
> Several of these trees were affected by hard flat gall of the flower cushions, which is quite different from the greenpoint and the flowery types, both of which are mostly globose, semi-hard, and borne on a central stalk of small diameter. These hard flat galls measured from 2.25 to 2.75 inches in diameter and from 0.75 to 1.75 inches in elevation. They were woody, very hard, and were firmly united with the wood of the supporting tree clear out to the circumference of the gall. The surface of the galls was very dark, corrugated, and undulating. Some of the galled cushions bore no flowers, others bore a few, and still others bore an abnormally large number of flowers.

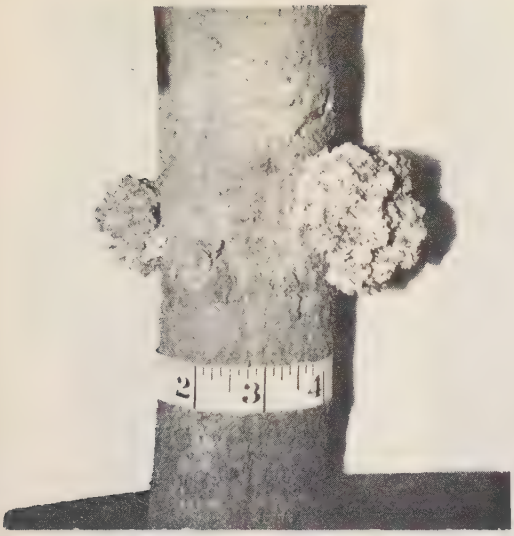

Fig. 1-A

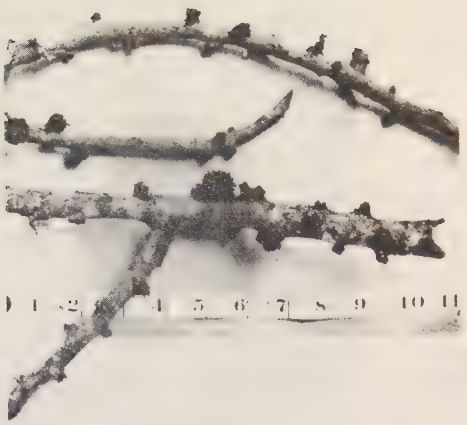

Fig. 1-B

Figure 1. GREENPOINT GALL. 1-A. Galls on main stem. 1-B. Galls on outer branches.

Fig. 5-A

Fig. 5-B

Figure 5. FAN GALL. 5-A. Branching fan, with flowers and leaves
5-B. Showing stem-outgrowths with very short internodes and bract-like leaves.

Fig. 2-A

Fig. 2-C

Fig. 2-B

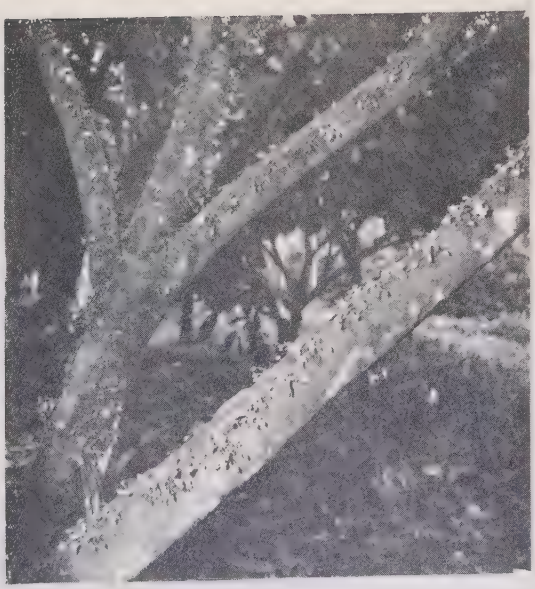

Fig. 2-D

Figure 2. FLOWERY GALL. 2-A. A flowery gall in full flower.
2-*B*. Flowery galls at termination of floration period.
2-*C*. Heavily galled basal limbs.
2-*D*. Normal floration of basal limbs.

Fig. 3-A

Fig. 3-B

Fig. 3-C

Figure 3. KNOB GALL. 3-A. Common spherical type of knob gall. *3-B.* Occasionally, the knob surface may be irregular. *3-C.* Showing on the same limb : (*a*) A large single knob; (*b*) A small single knob; and (c) multiple knobs developing from the same flower cushion.

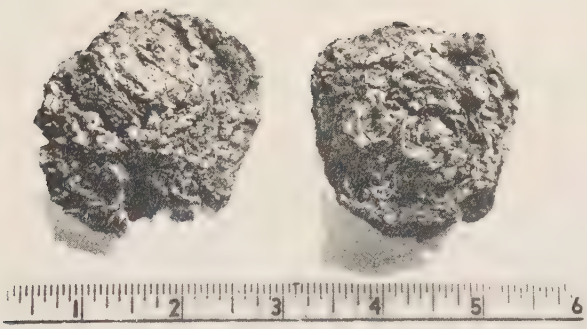

Fig. 4-A

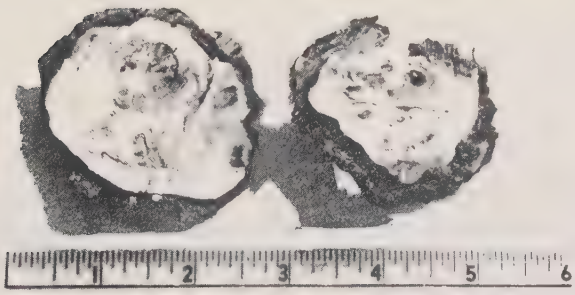

Fig. 4-B

Figure 4. DISC GALL. 4-A. Showing the dark, corrugated, undulating, upper surface of two galls. 4-B. Under surface of the two galls shown in 4-A, firmly united with the wood of the supporting limb.

On one tree, the galls were distributed along the straight trunk for a distance of nearly 20 feet from the soil line. In this same planting, typical specimens of knob gall were seen in a few of the flower cushions."

he term "Disc Gall" has been proposed as a more appropriate han the awkward term, hard flat gall. The authors recommend ance of the new term.

isc gall has not been recorded as yet in Costa Rica.

FAN GALL

ushion Galls of cacao, particularly of the flowery type, occ- lly develop branched, stem-like outgrowths, up to a few inches gth, the shape of which when in a group suggests a fan (Fig. 5). outgrowths are apt to have very short internodes. Some may lowers. Some may be in the form of single stems. The study -like growths is mostly in the observational stage.

SUMMARY

he term Cushion Gall is treated as a nonspecific designation l of the gall-like outgrowths from the flower cushions of ca- When using this term, reference should be made to the type of hat is meant.

ive types of galls or outgrowths are described, namely, green- gall, flowery gall, knob gall, disc gall, and fan gall. Span- uivalents of the English names are given.

he greenpoint and the flowery gall types are by far the most ant and the most widely distributed.

RESUMEN

La expresión agalla del cojinete se usa como una designación no específica para todo tipo de tumor en forma de agalla que se encuentra en el cojinete floral del cacao. Al usar este término, se debería especificar el tipo de agalla al cual se hace referencia.

Se describen cinco tipos de agallas o tumores; i.e. la agalla de puntos verdes, la agalla floral, la agalla en forma de perilla, la agalla en forma de disco, y la agalla de abanico. Los nombres se dan tanto en inglés como en español.

Las agallas de puntos verdes y las agallas florales son las más importantes y las más intensamente diseminadas.

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REACCION DE DIFERENTES CLONES Y PROGENIES HIBRIDAS A LA BUBA O CUSHION GALL DEL CACAO *

Ricardo Alvarado,** Enrique Ampuero,*** Kenneth D. Doak ****

INTRODUCCION

La "Buba" o "Cushion Gall" es una enfermedad del cacao caracterizada por una hipertrofia del cojinete floral en el tronco y las ramas. Generalmente el árbol enfermo produce pocas mazorcas y en caso de severo ataque el árbol puede volverse improductivo.

En la actualidad, la enfermedad ha sido observada en Nicaragua, Costa Rica, Panamá, Trinidad, Surinam, Colombia, Ecuador, Perú, Brasil, Guayana Inglesa, México, Ghana, Nigeria, Ceilán y Venezuela. No constituye la buba en estos países un problema grave, excepto en ciertas zonas de Nicaragua, Colombia y Costa Rica, pero se considera potencialmente de serio peligro. La causa de la enfermedad aún se desconoce, pero se sospecha que uno o más agentes biológicos están involucrados en la causa. Se piensa que la enfermedad es infecciosa y sistémica en los árboles. Es posible de que la buba pueda presentarse en áreas libres de la enfermedad debido a la diseminación o en el material de propagación recolectado de árboles enfermos. Todavía no ha sido posible desarrollar métodos adecuados de control.

Hace algunos años se observaron en el Ecuador pocos casos de buba, pero desde hace 2 años ha sido progresiva la incidencia de la enfermedad en la Estación Experimental Tropical de Pichilingue.

El objeto principal de este trabajo es presentar un inventario de la incidencia de buba en la colección de clones y progenies híbridas de la Estación Experimental Tropical de Pichilingue.

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** Estudiante egresado, becado por el American Cocoa Research Institute

*** Fitopatólogo. Director de la Estación Experimental Tropical de Pichilingue

**** Asesor del Departamento de Fitopatología. USOM/Ecuador.

REVISION DE LITERATURA

La buba ha sido descrita e ilustrada en algunas publicaciones. Po-
emente Garcés citado por Hutchins(2) dió la primera información que
ca la presencia de buba en Antioquia y Valle (Colombia), él la lla-
Verruga del Cojín Floral". Más tarde Lozada (7) en 1958 confirma la
rmedad en Colombia. El autor señala que los cambios producidos en los
nes florales se deben principalmente a un Eriophydae, aunque la iden-
cación específica no se ha determinado.

Kevorkian (6) en 1951, observó la buba en Nicaragua, Costa Rica y
má, estimando que en Nicaragua el 25% de los árboles estaban ataca-
y en algunas plantaciones alcanzaban hasta el 50% y 75% de los árbo-
Considera el autor que el agente causal puede ser un virus por la
raleza sistémica de la enfermedad.

Wellman y Orellana (10) en 1955, ratifican la presencia de buba en
ragua. Ellos en un aislamiento en medios artificiales de partículas
ológicas de agallas observaron colonias de fusarium, trichoderma, bac-
as y un hongo algodonoso que no fue identificado. También encontra-
gorgojos en la agalla.

Orellana (9) en 1957, informa la existencia de buba en Ceilán simi-
a la del hemisferio occidental.

Hutchins (1) en 1958, realizó un recorrido para determinar la distri
ón de la buba en América, encontrando en todos los países visitados
nfermedad, pero solo observó brotes serios en el este de Costa Rica,
de Nicaragua y norte de Colombia.

Imle y Havord citados por Hutchins (4) en 1959, encontraron buba en
a-Ghana y Nigeria, lo que fue confirmado más tarde por Tinsley cita-
mbién por Hutchins.

Los síntomas de la buba están bien descritos por Wellman y Orellana
y Hutchins (5). Este último autor describe los siguientes tipos de

La "buba floral" que tiene un gran número de flores muy compactas,
cuales se desarrollan completamente pero muy pocas veces se polini-
aturalmente. La "buba de puntos verdes" presenta en su superficie
gosa una profusión de pequeñas yemas o inicios florales, verdes, los
s no llegan a convertirse en flores desarrolladas. Ocasionalmente
tor ha observado otros tipos de buba denominados: "Knob Gall", "Hard
Gall" y una buba semejante a escoba.

En Costa Rica, Hutchins y otros (5) en 1959, realizaron una evalua-
de una colección de 27 clones UF en lo referente a susceptibilidad
tal a la buba del cacao. Ellos encontraron que 3 clones resultaron

libres de buba, 5 clasificadas como intermedia, 13 como extremadamente susceptible y 6 que no se clasificaron en ninguno de los 3 grupos anteriores por ser plantas muy jóvenes entre otras causas.

Rutchins (4) reportó en 1959 transmisión de la agalla de puntos verdes y agalla floral por medio de trasplante de tejido desde agalla típica a los pedúnculos de la mazorca de árboles libres de agalla. De 143 inoculaciones realizadas con tejidos de agalla de puntos verdes o sea 5.7% desarrollaron agallas de puntos verdes en el pedúnculo de la mazorca en donde la inoculación de la agalla floral por tejido de trasplantación a pedúnculos de mazorcas de árboles normales no han desarrollado resultados positivos hasta la presente.

Contrariamente a cuanto ha sido descrito en otros países, Malaguti (6) en 1959 en Venezuela observa que la buba es bastante común en plantas jóvenes, de 4 a 5 años cuando proceden de semilla y de 2 a 4 años cuando proceden de estacas. El autor informa que las selecciones clonales que se encuentran atacadas de buba son los clones UF-667, UF-221, ICS-1 y 95, SCA-6 y 12, Colombia-6 y diferentes selecciones venezolanas como Ocumare, Choroni y Chuao. El autor también ha observado agallas en plantitas de 8 a 10 meses, como Ocumare-24, así mismo, encontró los síntomas de la enfermedad en plantitas de semillas de 3 meses de edad, híbridas de las colecciones Ocumare-61 x Costa Rica-667 y Ocumare-73 x Costa Rica-667.

PROCEDIMIENTO USADO PARA LA EVALUACION

Durante el período del 15 de noviembre de 1959 al 30 de enero de 1960 fueron examinados en busca de síntomas de la buba 238 clones y las progenies híbridas de 66 cruces interclonales de la Estación Experimental Tropical de Pichilingue.

Los clones observados son clones introducidos de otros países y clones nacionales, tienen una edad que varía de 3 a 9 años. Las progenies híbridas tienen una edad de 7 a 8 años.

A cada árbol examinado se le dió una puntuación de acuerdo a la siguiente clave usada por Hutchins(5):

0 Sin evidencia de buba

+ Una o pocas bubas en la planta

++ Varias bubas en la planta, pero no todas las ramas afectadas

+++ Todas las ramas de la planta con numerosas bubas.

Se observó el tipo de buba floral en la mayoría de los árboles
ados; la buba de puntos verdes se encontró ocasionalmente. Para
to del uso de la clave se considera ambos tipos de buba bajo una
a denominación. Se registró la presencia de buba cuando tenía ge-
lmente en tamaño de un cuarto de pulgada. Las bubas más grandes
rvadas fueron de 2½ a 3 pulgadas de diámetro.

INCIDENCIA DE BUBA EN LA COLECCION DE CLONES DE LA ESTACION EXPERIMENTAL TROPICAL

De 238 clones examinados se registró la presencia de buba en 14
es.

En el cuadro No. 1 se presentan los clones atacados de buba, los
os que se ordenaron de acuerdo a la procedencia de la siguiente ma-
: clones de Costa Rica, clones de Colombia, clones de Trinidad y
es de Ecuador. La incidencia de buba se expresa en porcentaje.

Se observa, en general que la incidencia de buba es leve de acuer-
la clave.

En el cuadro No. 1 se nota que los clones UF son los más atacados
la buba, en especial los clones UF-667. Entre los 3 clones colom-
os que manifestaron agallas sobresalió el EET-269. En los clones
itarios se observó que el ICS-48 tiene el más alto porcentaje de
dencia de buba. De los clones ecuatorianos solo el clon EET-200
ltó atacado de buba.

Cuadro No. 1 - Incidencia de buba o cushion gall en 14 clones ordenados según su procedencia.

CLON	PAIS	No. ARBOLES OBSERVADOS	% DE INCIDENCIA DE BUBA	CLAVE +	++	+++
UF-667	Costa Rica	58	46.5	20.7	20.7	5.1
UF-221	Costa Rica	5	40.0	20.0	20.0	
UF-650	Costa Rica	70	20.0	11.5	8.5	
UF-654	Costa Rica	52	11.5	7.6	2.0	2.0
UF-676	Costa Rica	56	8.9	7.1	1.8	
UF-613	Costa Rica	59	6.7	6.7		
EET-269 ※	Colombia	93	24.9	16.2	8.7	
EET-270 ※	Colombia	164	9.7	5.4	4.3	
EET-268 ※	Colombia	71	7.0	5.6	1.4	
ICS-48	Trinidad	12	25.0	25.0		
ICS-40	Trinidad	18	5.5	5.5		
ICS-8	Trinidad	34	2.9	2.9		
ICS-1	Trinidad	1052	0.3	0.3		
EET-200	Ecuador	5	40.0	40.0		

※ Denominación dada en la Estación Experimental Tropical de Pichilingue.

INCIDENCIA DE BUBA EN LA PROGENIE HIBRIDA

De 66 cruces interclonales híbridos examinados se registró incidencia de buba en 28 cruces. En el cuadro No. 2 se observa los cruces que presentaron los síntomas de buba. Los clones padres de las progenies híbrida atacada de buba y su porcentaje de incidencia se presenta en el cuadro No. 3.

De acuerdo a la clave, la incidencia de buba en las progenies
las es leve.

Se observa en el cuadro No. 2 que los cruces ICS-1 x SCA-6,
50 x SCA-6, EET-248 x SCA-6, UF-667 x EET-196 y SCA-6 x EET-6
n los más altos porcentajes de incidencia de buba.

Con el objeto de averiguar si había una relación en la inciden-
e buba entre la progenie híbrida y los progenitores se tomaron
de agallas en los clones padres.

Lamentablemente no se pudo conseguir esta información completa,
e actualmente no existen algunos de los clones usados en los pro-
s de hibridaciones.

Se nota que muchos de los clones usados como padres no presenta-
uba. Es interesante observar que los cruces efectuados con los
s UF-667 y ICS-1 presentaron los síntomas de la agalla del coji-
tales como UF-667 x SCA-6, SCA-9 x UF-667, UF-667 x EET-196,
x SCA-6 y EET-166 x ICS-1. A pesar de que no se observó buba en
lones Scavina, sin embargo, las progenies con padres Scavina sí
ntan buba, este hecho es importante en los países que utilizan
clones en los programas de resistencia a Escoba de Bruja.

o No. 2 Incidencia de buba o cushion gall en las progenies híbridas de 28 cruces interclonales.

CRUCE		No. ARBOLES OBSERVADOS	% DE INCIDENCIA DE BUBA	CLAVE +	++	+++
5	x EET-6	13	38.4	38.4		
1	x SCA-6	30	36.6	36.6		
250	x SCA-6	44	36.3	27.3	6.8	2.2
248	x SCA-6	33	36.3	27.2	9.1	
5	x EET-12	4	25.0	25.0		
5	x SCA-6	53	18.8	18.8		
67	x SCA-6	12	16.6	8.3	8.3	
1	x EET-224	20	10.0	10.0		
10	x SCA-6	24	8.3	8.3		
12	x SCA-6	49	6.1	6.1		
12	x SCA-6	21	4.7	4.7		
18	x SCA-6	93	1.0	1.0		

Cuadro No. 2 (continuación)

CRUCE	No.ARBOLES OBSERVADOS	% DE INCIDENCIA DE BUBA	CLAVE +	++	+++
EET-248 x SCA-12	26	11.5	11.5		
CG* x SCA-12	41	4.8	4.8		
238 x SCA-12	49	4.0	4.0		
EET-156 x SCA-9	18	11.1	11.1		
SCA-9 x UF-667	21	9.5	9.5		
UF-667 x EET-196	11	63.6	63.6		
EET-6 x EET-174	15	13.3	13.3		
EET-166 x ICS-1	9	11.1	11.1		
EET-48 x EET-174	29	6.8	6.8		
EET-161 x EET-166	16	6.2	6.2		
EET-156 x EET-166	16	6.2	6.2		
EET-61 x EET-174	70	6.1	6.1		
EET-166 x EET-184	19	5.2	5.2		
EET-224 x EET-166	23	4.3	4.3		
EET-248 x EET-174	37	2.7	2.7		
EET-12 x EET-48	29	17.2	17.2		

Cuadro No. 3 Clones padres de la progenie híbrida atacada de bu
o cushion gall y porcentaje de incidencia de buba.

NOMENCLATURA DE LA ESTACION	DENOMINACION ORIGINAL	No DE ARBOLES OBSERVADOS	INCIDENCIA DE BUBA %	CLAVE +	++	++
EET- 6	C-2 Tr-880	3	0			
" 11	SCA-6	28	0			
" 12	C-2Tr-886	41	0			
" 48	Sta. Rosa 34	90	0			
" 50	Sta. Rosa 37	6	0			
" 61	San Javier 11	36	0			
" 62	Porvenir 7	23	0			
" 82	Pichilingue 24	*	-			
" 109	SCA-9	4	0			
" 110	SCA-12	6	0			
" 156	San Genaro 2	2	0			
" 161	Curiquingue 1	34	0			

adro No. 3 (continuación)

MENCLA-RA DE ESTA-ON	DENOMINACION ORIGINAL	No DE ARBOLES OBSERVADOS	INCIDEN-CIA DE BUBA %	+	++	+++
-166	San Carlos 3	*	-			
174	Mascota 1	*	-			
184	San Juan P. 1	37	0			
196	La Florida 85	*	-			
224	Tenguel 12	*	-			
238	Isla Bejucal 1	12	0			
248			0			
250			0			
274	ICS-1	1052	0.3	0.3		
313	UF-667	58	46.5	20.7	20.7	5.1

Clones que actualmente no existen en la Estación Experimental Tropical de Pichilingue.

DISCUSION

Los resultados obtenidos indican que el ataque de la buba c cushion gall en la colección de clones y progenies híbridas de c ces interclonales de cacao de la Estación Experimental Tropical Pichilingue no es grave aún. Se sospecha que la agalla del cojín te haya sido introducida en el material de propagación.

Los resultados en algunos países (5), (8), y los datos seña dos en el cuadro No. 1 confirman la evidencia de que algunos de clones UF son susceptibles a la buba. Cabe anotar que los clones UF-667 y UF-221 que tienen alto porcentaje de incidencia de buba la Estación Experimental, han demostrado en Venezuela (8) ser un de los principales clones que se encuentran atacados de buba.

Como es la primera inspección realizada no se puede afirmar los clones y progenies híbridas que hasta la fecha no han presen síntomas de buba, sean resistentes a ella. Es conveniente efectu inspecciones periódicas para observar el progreso de la incidenc de buba.

La posibilidad de que los clones Scavina usados como padres la progenie híbrida no tengan resistencia a la buba, complicaría panorama futuro de mejoramiento del cacao, por lo que se hace ne sario acumular más información de estos clones Scavina en alguno países.

También es necesario efectuar un inventario más amplio en l zonas cacaoteras del Ecuador para observar la intensidad y disem nación de la buba. El material híbrido de cruces interclonales s ría una buena fuente para futuros trabajos. Se podría averiguar hay segregación en la susceptibilidad a la buba. También puede s que la heterogeneidad de la población híbrida del cacao permita tener material resistente a la buba.

RESUMEN

1. Se presenta un inventario de la incidencia de buba en 238 cl y las progenies híbridas de 66 cruces interclonales de la Es ción Experimental Tropical de Pichilingue.

2. La buba se presentó en 14 clones; los clones UF-667, UF-221, ICS-48 y EET-200 tienen la más alta incidencia de buba.

Las progenies híbridas de 28 cruces interclonales muestran los síntomas de la buba. Los cruces UF-667 x EET-196, ICS-1 x SCA-6, SCA-6 x EET-6, EET-250 x SCA-6 y EET-248 x SCA-6 presentan los más altos porcentajes de incidencia de buba.

Se observa que muchos de los clones usados como padres de las progenies híbridas atacadas de buba no presentaron los síntomas. Los clones padres UF-667 y ICS-1 y sus progenies híbridas tienen ataque de buba.

Se recomienda: acumular más información de la incidencia de buba en los clones Scavina; realizar inspecciones periódicas y efectuar un inventario de la incidencia de buba en las zonas cacaoteras de Ecuador.

SUMMARY

A survey of cushion gall was made on clones and progenies of interal hybrid cacao at the Tropical Experiment Station in Pichilingue, ador. Fourteen clones had cushion gall out of 238 clones examined. most susceptible clones were UF-667, UF-221, ICS-48 and EET-200.

The progenies of 28 interclonal hybrids had cushion gall out of examined. The most susceptible hybrids were UF-667 x EET-196, -1 x SCA-6, SCA-6 x EET-6, EET-250 x SCA-6 and EET-248 x SCA-6. eral hybrid progenies had cushion gall but the parent clones that up the hybrids did not express symptoms at the time of the sur-

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SUMMARY OF DISCUSSION

T.W. Tinsley (WACRI)

In Nigeria and West Africa the only gall present is a gall mbling the greenpoint. The incidence of galls in West Africa ears to be much less than in the Western Hemisphere and, further-, seems to be more prevalent in the few Trinitario types there in Amelonado. Recent work has isolated a bacterium bacterium Tumefasciens from gall tissue and inoculations with this erium had produced galls in healthy plants. As far back as 1923 H.A. Dade had reported the occurrence of galls and the same erium was isolated at the time.

B.G Bartley (ICTA)

Observations on the so-called "Greenpoint" type of "Cushion" indicate that these are largely formed by the proliferation he chupon meristematic tissue. The paper by Gorenz states these galls are formed only on flowering plants. However, s have been observed on young trees and Malaguti reports their rrence on 3-month old seedlings. It is also possible to produce s on the cotyledonary axil of very young seedlings. It would ar that the formation of galls is independent of flowering and term "Cushion" Gall is misleading. It is suggested that another , such as Chupon Gall be used instead.

PAPERS ON SOILS, NUTRITION AND NUTRITIONAL PHYSIOLOGY

SOME RELATIONSHIPS BETWEEN SOIL AND AIR TEMPERATURES IN A CACAO FIELD*

F. Hardy **

INTRODUCTION

The temperature data discussed in this article were obtained over a period of 79 weeks in a 40 years' old cacao field situated on an alluvial flat in an estate north of Arima in the Northern Range of Trinidad. The annual yield of the field was 600 lb. of cured cacao per acre. The cacao tree population was a Trinitario mixture with 12 percent blanks and supplies. The spacing was 12 x 12 feet. Uniform Immortelle shade (Erythrina poeppigiana) was provided. Measurements made with a light meter proved that the shade trees cut off 66 percent of the sunlight. The soil is River Fine Sand having Grade II productivity rating.

There were three plots adjacent to each other, namely, (I) Bare Plot (1/10 acre) from which all cacao leaves and other litter were regularly removed, (II) Litter Plot (1/5 acre) which was left untouched, and (III) Mulch Plot (1/10 acre) over which a layer three inches thick of sugar cane fibre (bagasse) was spread 2 weeks before the beginning of the experimental period. This layer was replenished in the 14th week. Each of the plots was clean-weeded, the drains recut and the trees well pruned. A heavy leaf fall occurred soon after the experimental period began and this, together with the transference of prunings and litter from the Bare Plot to the Litter Plot, gave a thick accumulation of vegetable residue on the Litter Plot. Fertilisers were added on three occasions during the first wet season to the Bare Plot and to the Litter Plot in order to compensate for the nutrients liberated by the decomposing bagasse. As a result of these various operations, the canopy of the trees greatly improved and leaf shedding became diffuse and much diminished during the first wet period and the dry period that followed.

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* Work carried out at the Imperial College of Tropical Agriculture, Trinidad.

** Coffee, Cacao and Rubber Technical Services, Plant Industry Department, Inter-American Institute of Agricultural Sciences, Turrialba, Costa Rica.

Air temperature was measured by a recording thermohygrograph by a maximum and minimum thermometer installed in a Stevenson een four feet above ground level set up in the Litter Plot. se instruments were checked weekly against a standard thermo- er and suitable corrections were made weekly to the recorded perature readings.

Soil temperature was measured in each of the three plots by rate mercury-in-steel distance recording thermometers whose bulbs were buried horizontally at 3 inches depth below the surface in each plot. These instruments were checked weekly nst standard thermometers inserted vertically in groups of or six into the soil in the vicinity of the bulbs. The charts he recording thermometers were changed weekly after checking, the weekly means of the corrected daily maximum and minimum peratures were recorded.

Rainfall was measured in inches per week by a recording rain e checked by a standard funnel-type rain gauge. Evaporation measured in cubic centimeters per week by paired Piche evap- eters. Observations were made weekly of leaf shedding, leaf hing and other physiological processes occurring in the cacao s.

For purposes of comparison, air temperature and soil temper- e, registered at the Meteorological Station of the Imperial ege of Tropical Agriculture, which is about 16 miles south- of the plots, were tabulated for the same weekly periods. e data are not strictly comparable with the cacao plot data use they represent the absolute maximum and minimum temper- es for each week and not the weekly mean daily temperatures, also because soil temperature was measured at one inch depth not at three inches. The I.C.T.A. data refer to a grassed-over sed site.

RESULTS

The temperature values in degrees Fahrenheit were recalcula- as 5-week moving averages and plotted in graphs (See accompa- g diagram). The total period is subdivided in the diagram by ical lines into wet and dry seasons. In each temperature graph, 77°F. line is thickened to serve as datum. Actually it repre- s Mohr's critical temperature above which the rate of decom- tion of forest litter exceeds the rate of its accumulation on forest floor. The weekly rainfall and evaporation values are plotted in the same diagram.

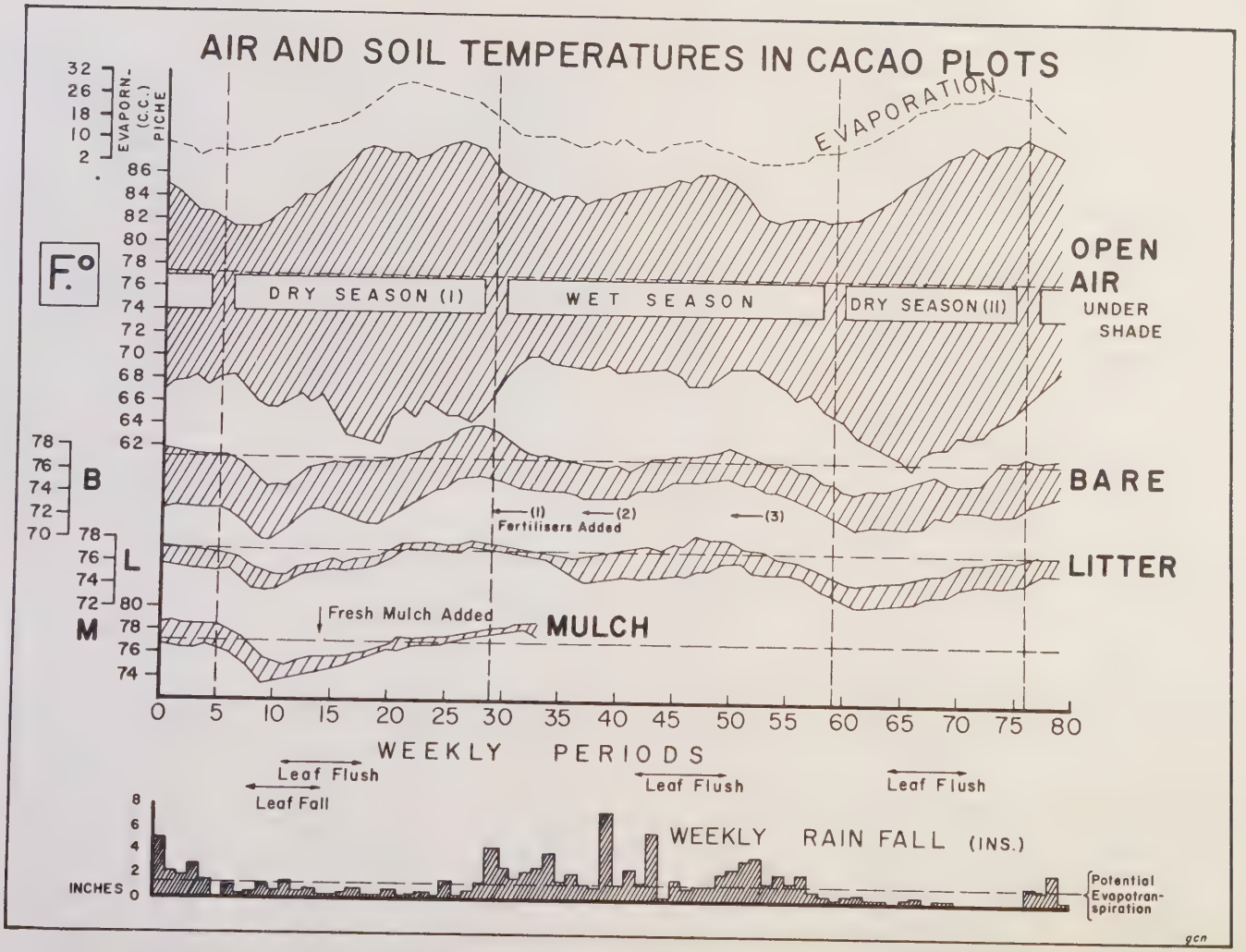
Leaf shedding, as has already been stated, was profuse during the early part of the first dry season but at no other time during the experimental period. Leaf flushing occurred on several occasion but mostly in the middle of each dry season when the maximum temperature exceeded 83º F. and when the daily range of air temperature exceeded 16º F., which accords with the results obtained at this site by E.C. Humphries (1) and at La Lola, Costa Rica, by P. de T. Alvim in his studies of thermoperiodism in cacao (2).

The actual temperature data are summarized in a table in which mean values for weekly periods in the dry and the wet seasons are set out in columns. The temperature data for the I.C.T.A. grass plot are presented in the same table for comparison. The table also includes at the bottom weighted mean values for the wet and the dry season from which certain generalized conclusions can be drawn.

DISCUSSION AND CONCLUSIONS

1. Average temperature: The weighted mean values given at the bottom of the table show that within the cacao field the average temperature throughout the whole period differed by less than one degree for both air and soil. It was 76.0º for air, and 75.1º for bare soil, 75.8º for soil covered with litter and 77.0º for mulched soil. The slightly higher temperature for mulched soil is attributed to fermentation of the bagasse. The temperatures are all slightly below Mohr's critical temperature, 77º. By contrast, the weighted mean values for the I.C.T.A. Meteorological Station grass plot were about 2º higher than in the cacao field for air but about the same for soil at 1 in. depth.

2. Seasonal fluctuations of average temperature: The weighted mean values for wet and dry seasons show that the average temperature for the wet season (summer) was between one and two degrees higher than that for the dry season (winter) both for air and soil, but not for the I.C.T.A. grass plot which showed less seasonal variation for air temperature and a higher average soil temperature for the dry season (winter) than for the wet season (summer).


AIR AND SOIL TEMPERATURES IN CACAO PLOTS
EVAPORN. (C.C.) PICHE
32
26
18
10
2
EVAPORATION
F°
86
84
82
80
78
76
74
72
70
68
66
64
62
DRY SEASON (I)
WET SEASON
DRY SEASON (II)
OPEN AIR UNDER SHADE
B
78
76
74
72
70
BARE
(1) (2) (3)
Fertilisers Added
L
78
76
74
72
LITTER
M
80
78
76
74
Fresh Mulch Added
MULCH
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80
WEEKLY PERIODS
Leaf Flush
Leaf Fall
Leaf Flush
Leaf Flush
WEEKLY RAIN FALL (INS.)
INCHES
8
6
4
2
0
Potential Evapotranspiration
gcn

Week	CACAO PLOTS												GRASS PLOT (I.C.T.A.)					
	AIR			SOIL									AIR			SOIL		
				BARE PLOT			LITTER PLOT			MULCH PLOT						GRASS PLOT		
	Max	Min	Dif	Max	Min	Dif	Max	Min	Dif	Max	Min	Dif	Max	Min	Dif	Max	Min	Dif
				WET SEASON														
1- 5	83.3	67.8	15.5	77.4	72.8	4.6	76.9	75.3	1.6	78.5	76.5	2.0	86.0	68.8	17.2	79.7	65.5	14.2
				DRY SEASON														
6-17	83.8	65.7	18.1	76.0	71.5	4.5	75.7	74.6	1.1	75.9	74.5	1.4	86.8	65.7	21.1	83.7	64.6	19.1
18-29	88.3	64.8	23.5	78.6	73.8	4.8	77.3	76.9	0.4	77.3	76.8	0.5	91.5	68.7	22.8	95.6	68.8	26.8
				WET SEASON														
30-44	84.8	69.3	15.5	77.1	74.4	2.7	77.0	75.5	1.5	78.6	78.0	0.6	88.1	70.2	17.9	84.5	68.0	16.5
45-59	84.1	67.9	16.2	77.1	74.5	2.6	77.2	75.2	2.0	--	--	--	88.4	68.8	19.6	83.8	67.6	16.2
				DRY SEASON														
60-76	86.8	63.4	23.4	75.8	72.2	3.6	75.5	73.5	2.0	--	--	--	89.1	65.9	23.2	83.4	65.6	17.8
				WEIGHTED MEAN VALUES														
WET	84.9	68.5	16.4	77.1	74.2	2.9	77.1	75.4	1.7	78.7	77.1	1.6	86.5	69.5	17.0	83.5	67.5	16.0
DRY	86.4	64.5	21.9	76.7	72.5	4.2	76.1	74.8	1.3	76.6	75.6	1.0	89.1	66.7	22.4	87.0	66.3	20.7
				AVERAGE VALUES														
WET	76.7			75.6			76.2			77.9			78.0			75.5		
DRY	75.4			74.6			75.4			76.1			77.9			76.6		
YEAR	76.0			75.1			75.8			77.0			77.9			76.0		

3. Maximum temperature: The weighted means show much higher values for maximum air temperature throughout the whole period than for soil temperature, the mean differences being 7.3º for the wet season and nearly 10º for the dry season. The difference between the mean maximum soil temperature in the first two plots was negligible, but the mean maximum temperature in the mulched plot was appreciably higher because of fermentation. By contrast, the weighted mean maximum temperature for the I.C.T.A. grass plot was 3º higher in the wet season and 2º higher in the dry season for air than for soil. This may be explained by the facts that (i) the soil thermometer bulb was buried at a shallower depth, (ii) the soil was not shaded by trees at the I.C.T.A. Station and (iii) the values are based on absolute maximum weekly temperatures which may be somewhat higher than the mean values.

4. Seasonal variation of maximum temperature: The line for maximum air temperature in the graph shows great seasonal fluctuation, the maximum temperature varying from 81º at the beginning of the first dry season to 90º at the end of the second dry season, a range of 9º F. The maximum air temperature line runs closely parallel with the evaporation line which implies that high daily maximum air temperature is associated with aridity in the environment and low daily maximum air temperature with humidity.

The maximum soil temperature lines, by contrast, show lesser seasonal fluctuations than the maximum air temperature line. They also show an appreciable lag behind it. The amplitudes of the seasonal fluctuations were about 6º for the bare soil but only about 4º for the soil covered with litter and with mulch.

The maximum air temperature fluctuated around the 85.6º line (mean maximum) and maximum soil temperatures around 76.9º 76.6º and 77.6º for the three plots. Evidently, litter and mul greatly diminished both the degree and the rate at which the soil warmed up during the dry season and cooled down during th wet season.

Similar seasonal fluctuation in maximum air temperature occurred at the I.C.T.A. site but there the maximum soil temperature fluctuated even more than that of the air, presumably because of the absence of shade and the shallowness of the soil.

Minimum temperature: The weighted means for minimum temperature show much lower values throughout the whole period for air than for soil, the differences being about 7º for the wet season and nearly 10º for the dry season. These values were about as much below the mean temperatures as the maximum temperatures were above it. Lowest mean minimum soil temperature was shown by the bare soil and highest by the mulched soil.

By contrast, the weighted mean minimum temperature for the I.C.T.A. grass plot was 2º higher for air than for soil in the wet season and 0.4º higher in the dry season, which are the reverse of the conditions in the cacao plots where the soil did not cool down to the same extent as did the air.

Seasonal variation of minimum temperature: The line for minimum air temperature in the graph shows similar fluctuations as the maximum air temperature except that they occur in the reverse direction. Thus, when the maximum rose, the minimum temperature sank. The minimum air temperature varied from 70º at the beginning of the wet season to about 61º in the middle of each dry season, a range of 9º, as in the case of maximum air temperature. Low daily minimum temperature is associated with aridity in the environment and high minimum with humidity.

The minimum soil temperature lines show lesser seasonal fluctuations than the minimum air temperature line but they display a striking peculiarity in that, unlike the minimum air temperature lines, they run nearly parallel to the maximum soil temperature lines. This implies a great lag in the rate at which heat escapes from the soil, even when the soil is bare. The amplitude of the fluctuation was consequently nearly the same as that of the maximum soil temperature, namely, about 6º for bare soil and 4º for litter-covered soil and for mulched soil.

Minimum air temperature fluctuated around 66.5º (mean minimum) and minimum soil temperatures around 73.3º, 75.1º and 76.3º for the three plots respectively.

Similar seasonal fluctuations in minimum air temperature occurred at the I.C.T.A. site but, in contrast to the cacao field, minimum soil temperature showed similar fluctuations as minimum air temperature. This again might be explained by the absence of tree shade and by the shallowness of the layer of soil to which the temperature data refer.

Daily fluctuation of temperature: In the graphs, the spaces bounded by the maximum and the minimum temperature lines are shaded so as to indicate the magnitude of the daily fluctuations in temperature and also the essential difference between air temperature and soil temperature stressed in the last paragraph, namely that, whereas minimum air temperature falls as maximum air temperature rises, minimum soil temperature rises as maximum soil temperature rises. In the diagram this striking fact is shown by the shape of the shaded band which is that of a fairly uniform parallel strip in the case of soil temperatures although it alternates slightly in width for dry and wet seasons. The width of the band is very much greater for air temperature than for soil temperature and somewhat wider for bare soil than for either litter-covered soil or mulched soil. The average widths of the bands, or the magnitudes of the mean daily fluctuation in temperature, are 19.1º for air, 3.5º for bare soil, 1.5º for litter-covered soil and 1.3º for mulched soil.

The narrowest part of the shaded strip in the graph for the Litter Plot marks the period when this plot was covered to considerable depth with litter and prunings. Later, as these residues diminished in bulk through decomposition and were not replenished by freshly-fallen leaves, the width of the strip increased which implies that the range of daily temperature increased. Unfortunately, the recording thermometer set up in the Mulch Plot failed in the 33rd. week and could not be replaced. Nevertheless, the effect of the increase on mulch thickness on soil temperature is clearly shown in the graph.

Daily fluctuation of temperature in the surface soil of the grass plot at ICTA greatly exceeded that in the soil of the cacao plots and differed but little from the daily fluctuation of air temperature, as is clearly shown by the data in the table. Whereas the weighted means of the daily soil temperature variations in the cacao plots ranged from about 3.5º in the Bare Plot to an average of 1.4º in the plots covered with litter or mulch, it was about 18.3º in the grassed over soil. This great difference may be attributed to the exposure of the soil to direct sunlight, to the lack of an insulating cover and to the shallow depth of the soil layer whose temperature was measured.

Physiological significance of the results: The fact that the presence of a layer of litter or of mulch, if sufficiently thick, greatly reduces or practically eliminates daily fluctuations of temperature in the soil immediately beneath it implies that the surface feeding roots of the cacao tree are not subjected under these circumstances to large variations in temperature which presumably might adversely affect their activity.

ACKNOWLEDGEMENT

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f Tropical Agriculture, Trinidad, for permission to publish
ese temperature data which were collected during the writer's
nure of office as a staff member of that College.

SUMMARY

This article presents data for air and soil temperatures
llected over a period of 79 weeks in a typical Northern Range
lley cacao estate in Trinidad and in a grass plot at ICTA.

Soil temperature was measured in three plots, one of which
s maintained devoid of litter, one left untouched, and one
vered with bagasse mulch.

The mean temperature data for a whole year obtained in this
vestigation may be summarised thus:

Cacao Plots

(i)	Air inside shaded cacao plot:	76º ± 9.5º F
(ii)	Bare soil, 3 ins. depth:	75º ± 1.75º F
(iii)	Litter-covered soil: ditto	76º ± 0.75º F
(iv)	Mulched soil: ditto	77º ± 0.65º F

Grass Plot ICTA

(v)	Air over exposed grass plot:	78º ± 10.0º F
(vi)	Grassed-over soil, 1 in. depth:	76º ± 9.2º F

The physiological significance of these results is that they
monstrate the great efficacy of a cover of litter or mulch in
ulating the temperature of the soil surrounding superficial ca-
roots, in that the cover almost entirely eliminates daily tem-
ature fluctuation.

RESUMEN

Este artículo presenta datos de temperaturas del suelo y del aire colectados durante un período de 79 semanas en una finca típica de cacao de Trinidad de la cordillera del Norte y en una parcela de pastos en el ICTA.

La temperatura del suelo se midió en tres parcelas, una de las cuales se mantenía limpia de basuras, otra sin limpieza y otra cubierta con una capa de bagazo.

A continuación se resume los datos de temperatura media para un año obtenidos en esta investigación:

Parcela de Cacao

(i)	Aire dentro de una parcela sombreada de cacao:	76º ± 9.5º F
(ii)	Suelo limpio, a 3 pulgadas de profundidad:	75º ± 1.75º F
(iii)	Suelo cubierto con basura:	76º ± 0.75º F
(iv)	Suelo con cobertura de bagazo	77º ± 0.65º F

Parcela de pastos: ICTA

(v)	Aire en parcela de pastos sobre expuesta:	78º ± 10.0º F
(vi)	Suelo con pasto, 1 pulgada de profundidad:	76º ± 9.2º F

El significado fisiológico de estos resultados es que éstos demuestran la gran eficacia de proteger el suelo con basura o cobertura para regular la temperatura del suelo que rodea a las raíces superficiales de cacao, por el hecho de que la cobertura elimina casi enteramente las fluctuaciones diarias de temperatura.

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DOCE MESES DE EVAPOTRANSPIRACION POTENCIAL EN CACAO

Cristobal Navarrete-Sanchez*

INTRODUCCION

Este es un informe de progreso del trabajo presentado en la I Conferencia Inter-Americana de Cacao celebrada en Palmira, Colombia en 1958. En esa ocasión se dieron resultados de sólo seis meses, era la intención, dar a conocer las técnicas de evapotranspirometría aplicadas por primera vez al cultivo del cacao. En el presente avance se dan los datos y algunas conclusiones de los estudios de evapotranspiración potencial del cacao durante doce meses.

Mucho se ha dicho de la industria cacaotera en el Valle Geográfico del Río Cauca en Colombia. La mayoría de los técnicos que han visitado la zona, afirman que el cacao se encuentra creciendo en esta zona en una forma marginal (Alvim, 1) debido a dos factores fundamentales: las condiciones climáticas y los altos costos de las tierras. Se atribuye gran parte en los bajos rendimientos del cacao en esta zona, a la baja precipitación registrada; Ibarra dice que el régimen pluviométrico de la zona es de tipo intertropical, en el cual las lluvias están comprendidas entre 1.000 y 2.000 mm al año. Datos de 20 años demuestran que la precipitación en la zona es de 1.008 mm en promedio.

Debido a las grandes controversias presentadas en relación con el cultivo del cacao en el Valle del Cauca, en cuanto al agua se refiere, la ex-Campaña Nacional de Cacao de la Caja Agraria de Colombia, emprendió estudios tendientes a determinar la relación que existe entre el cacaotero-suelo-agua. En la actualidad atiende la investigación cacaotera de Colombia el Departamento de Investigaciones Agropecuarias (D.I.A).

MATERIALES Y METODOS

En el trabajo presentado durante la VII Conferencia Interamericana de Cacao, se dieron amplios detalles de los métodos

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*Profesor, Universidad Central de Venezuela, Maracay; anteriormente Fitofisiólogo, Asesor de Investigación, Campaña Nacional de Cacao, Colombia.

utilizados en estos estudios. En esa oportunidad se presentó diseños originales sobre los evapotranspirómetros usados para determinar los requerimientos de agua por el cacaotero.

RESULTADOS Y DISCUSION

En la Tabla No.1 se dan los resultados de doce meses de evapotranspiración potencial para cada uno de los cuatro evapotranspirómetros; los promedios de los mismos; la precipitación durante esos doce meses obtenida en la misma plantación y la eficiencia del agua de lluvia durante el período informado. Esta eficiencia fué obtenida dividiendo la precipitación por la evapotranspiración potencial. Según esta información, se nota un ascenso en la evapotranspiración potencial durante los meses de febrero, marzo, y abril para entonces encontrar un descenso suave en el mes de mayo; desde mayo hasta enero de 1959 hay un aumento en la rata de evapotranspiración en el cacao en esta zona.

La tabla No. 2 indica que las diferencias de evapotranspiración potencial entre los meses son altamente significativas. Esto parece indicar que los requerimientos de agua por el cacaotero no son los mismos todos los meses del año. Hechos los cálculos del coeficiente de correlación entre la rata de evapotranspiración y la precipitación, resultó ser de mas 0.31. Si se mira la gráfica No. 1, parecería que existiera una correlación negativa entre la evapotranspiración y la precipitación; sin embargo, hechos los cálculos, la prueba de significación para el coeficiente de correlación demostró que no existe una asociación entre esos dos factores, o sea, la evapotranspiración y la precipitación son independientes. Esto está de acuerdo con Thornthwaite (3) quien dice que no existe ninguna correlación entre la precipitación y la rata de evapotranspiración potencial, ya que uno y otro fenómeno tienen causas diferentes.

Como el objetivo fundamental en este tipo de estudios es ver hasta donde es eficiente el agua de lluvia para los cultivos, vista la información en conjunto aquí presentada, se puede decir que la eficiencia del agua de lluvia para estos doce meses de evapotranspiración es tan sólo del 67%. Esto indicaría, si las condiciones climáticas se mantuvieran constantes en el Valle del Cauca que el cacaotero en esta zona necesitaría un 33% de riego suplementario. Hay tres meses, sin embargo, en que la eficiencia del agua de lluvia es de 221%, 222% y 124% para los meses de abril, mayo y diciembre respectivamente; la distribución, entonces, de la precipitación viene a agravar más la situación.

Tabla 1 Evapotranspiración potencial en cacao y precipitación en Milímetros para los meses de febrero de 1958 a enero de 1959

MESES	EVAPOTRANSPIRACION POTENCIAL					Precipitacion	Eficiencia de la Precipitacion %
	Evapotranspirometros No. 1	2	3	4	Promedio		
Febrero (1958)	65.37	62.45	85.39	85.47	74.67	31.5	42.19
Marzo	75.44	82.35	88.79	83.10	82.42	52.2	63.33
Abril	67.90	65.94	47.30	52.70	58.46	129.5	221.52
Mayo	50.35	57.73	55.49	44.52	52.02	115.5	222.02
Junio	58.92	77.34	54.38	43.20	58.46	14.5	24.80
Julio	67.88	85.23	58.75	58.13	67.50	9.3	13.77
Agosto	67.95	70.08	80.06	82.76	75.66	10.0	13.21
Septiembre	101.16	111.28	70.68	83.96	91.77	27.8	30.29
Octubre	114.32	119.35	88.23	94.36	104.07	41.6	39.97
Noviembre	86.25	106.73	68.71	70.73	83.11	54.7	65.82
Diciembre	88.56	114.37	59.03	75.76	84.43	104.9	124.24
Enero (1959)	110.58	120.99	90.81	89.40	102.95	36.9	35.84
Total					935.50	628.4	

Tabla 2 Análisis de variación de las lecturas de los evapotranspirómetros

Fuente de variación	G. de L.	S. de C.	Variación	F
Evapotranspirómetros	3	2,700.03	900.01	6.720**
Meses	11	12,573.92	1.143.08	8.535**
Error	33	4,419.59	133.92	
Total	47	19,693.55		

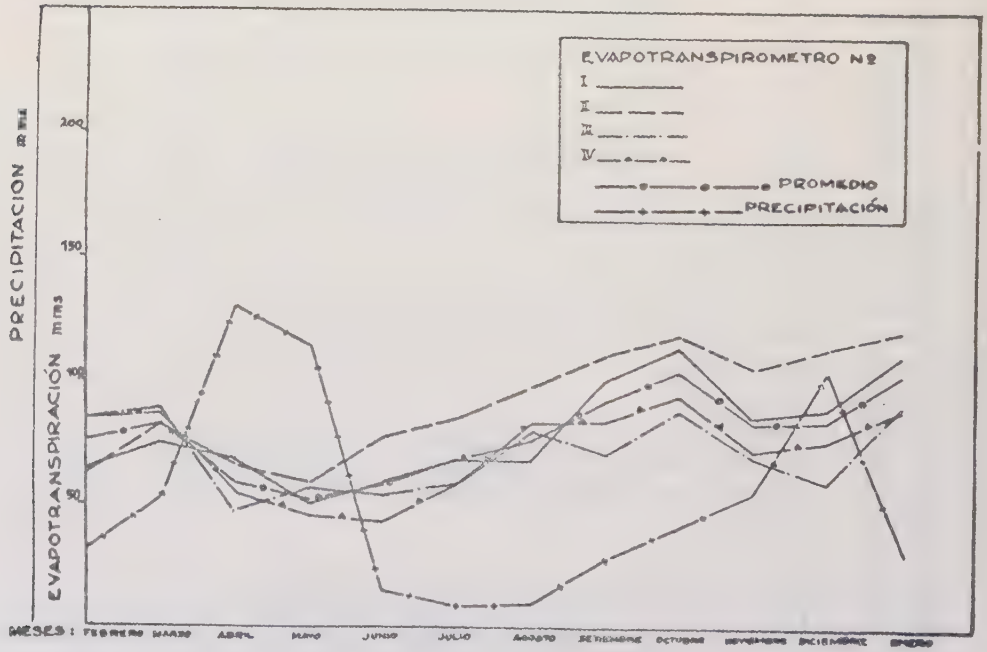

FIG. VALORES MENSUALES PARA LA EVAPOTRANSPIRACIÓN POTENCIAL EN CACAO (TEOBROMA CACAO) Y PRECIPITACIÓN 1958 PALMIRA - COLOMBIA

** Significativo al 1%

Si la situación arriba presentada se mantuviera constante, gnificaría que sólo hay que aplicar un 33% de riego suplemen- rio? Nosotros creemos que no. Estos datos de evapotranspira- ón sólo incluyen los requerimientos de agua por los árboles de mbrío. No sabemos cuales puedan ser estos requerimientos, asu- mos, sin embargo, dado el vigor de los árboles de sombra, que tos sean superiores a los del cacaotero. Según lo anterior, el ua que se requiere para que el cacao progrese normalmente bajo mbra, sería mayor que el doble del agua determinada para el ca- o solamente. La gran dificultad que se encuentra en los culti- s que crecen bajo sombra como el cacao y el café, es la compe- ncia por nutrientes y agua entre el cultivo principal y los boles de sombra.

La experiencia ha demostrado que mediante estudios de evapo- anspiración se puede lograr determinar los requerimientos de ua por la mayoría de las plantas; estos estudios deben condu- rse, sin embargo, durante un gran número de años. Estas técni- s podrían ser combinadas también con las de atmometría, las ales han dado muy buenos resultados en el estado de California eihmeyer, 4).

CONCLUSIONES TENTATIVAS

Según los datos aquí consignados, el arbol de cacao durante s doce meses citados requirió en promedio 935.50 mm de agua; éstos el agua de lluvia sólo suministró 628.4 mm Según esto, requiere aplicar un 33% de riego suplementario, sin tener en enta los requerimientos de agua por los árboles de sombrío. lo durante tres meses la precipitación fué superior al consumo l agua por el árbol de cacao. Se necesita más tiempo para sa- r conclusiones más valederas. Un estudio paralelo de atometría debería emprender para buscar una correlación entre el uso del ua, o evapotranspiración y la diferencia acumulativa en evapora- ón entre el bulbo negro y blanco en los atmómetros de Livingston.

AGRADECIMIENTOS

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RESUMEN

En este informe sobre evapotranspiración potencial en cacao, se presentan datos de doce meses. El experimento se inició en Colombia en 1958 en el Valle Geográfico del Rio Cauca. Existen diferencias altamente significativas en los valores mensuales de la evapotranspiración potencial, esto indica que el uso del agua por el cacao no es el mismo en todos los meses del año; no existe correlación entre la rata de evapotranspiración potencial y la precipitación; se requirió un 33% de riego suplementario, ya que la precipitación sólo suministró el 67% de los requerimientos del agua por el cacao sin tener en cuenta los árboles de sombrío; se considera que el uso del agua en una plantación normal de cacao en el Valle del Cauca que crezca bajo sombra, es superior a la aquí indicada. Se hace una recomendación a los países productores para que combinen las técnicas de evapotranspirometría con las de atmometría; esto ha dado muy buenos resultados en el estado de California con otros frutales.

SUMMARY

The author presents in this report the results of a 12-month period of potential evapotranspiration in cacao. The experiment was conduced in Palmira, Colombia and was started in February 19[illegible]. According to the information given there is a significant difference in potential evapotranspiration between the 12 months reported; there is no correlation between potential evapotranspiration and rainfall. Rainfall supplied only 67% of the water required in the 12-month period reported here; the total rainfall was 628.4 mm and the total potential evapotranspiration 935.50 mm. in the 12 months.

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CULTURAL AND MANURIAL EXPERIMENTS, RIVER ESTATE - A REVIEW

G.K. Maliphant*

The purpose of this paper is to bring together the available ormation on the practice of growing cacao in River Estate, idad and from the study of such data to identify the main blems to be considered whenever cacao is grown. There will be tle mention of disease control and breeding as these subjects l be treated elsewhere in the Conference.

Cultural experiments on cacao have been carried out in River ate for nearly 60 years, but the early experiments were severely dicapped by very variable material, coefficients of variability yield from tree to tree ranging from 75% to 100%, necessitating ge increments in yield for any particular treatment to become nificant. In addition the statistical design of experiments so ily accepted today was virtually unknown. Some later experiments l budded seedling material, so reducing variability to 55% in e cases. In 1949 the first cultural experiments using clonal erial and efficient statistical designs were planted. Earlier eriments with clonal material were planted in the years from 7 - 1942, and again from 1947 - 1950, but these were in the main nal trials. However some preliminary results were obtained from se experiments of the effects of fertilisers on shaded cacao.

Three main types of treatments can be distinguished in the eriments at River Estate, viz. fertilisers, organic manures, tivations, but it must be remembered that any one experiment may tain treatments from more than one of these groups. Superimposed these treatments are two other important variables, shade and cing. The results of the more recent experiments will be considered st, and the conclusions considered in the light of earlier experi-ts.

ponses to fertiliser

Fertiliser application in May of each year. (Table 1).

When N-P, and K-fertilisers are applied alone to unshaded close spaced cacao it is apparent that highest yields from N-treated plots were reaped at the lowest level of application, whereas from P- and K-treated plots the intermediate levels of application were approaching the optimum. The reduction in yield at higher levels of N-fertiliser was offset by applications of

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*Regional Research Centre, Imperial College of Tropical Agriculture, Trinidad.

P- or K-fertiliser. Similarly the reduction in yield from P-fertilised plots when the rate of application was raised from R_2 to R_3 was partially offset by application of K-fertiliser. From the point of view of the economist the best yields were obtained by applying N-, P-, and K- fertiliser all at level R_1, i.e. 450lb of ammonium sulphate, 150lb of double superphosphate, and 300lb of potassium chloride per acre per annum.

Yields from shaded wide spaced cacao were considerably lower than those from unshaded close spaced cacao, and the optimum levels of application of all three fertilisers was R_2, but the ameliorating effects of P- or K- fertilisers on the responses to the other fertilisers was much smaller, so that the best application was P- fertiliser at level R_2, when an average increment over 5 years of 209lb dry cacao per acre per annum was obtained.

With the more intense shade conditions of close spaced shaded cacao the optimum dressing was P- and K- fertilisers. However with the existing experiments the effect of higher levels of application have not been studied with this combination of shade and spacing. With unshaded wide spaced cacao N- and either P- or K- fertilisers gave the best yields, (average yields 1396 and 1427 lb dry cacao per acre per annum for 5 years respectively).

b) Fertiliser application in May and September of each year. (Table

When fertiliser applications were split, 50% in May and 50% in September, the necessity of avoiding an imbalance in the fertilisers applied as illustrated above also requires study. The various interactions of the fertilisers are illustrated in Table II, from which it becomes obvious that the best yields were obtained from applying all three fertilisers at level R_2, to unshaded close spaced cacao splitting the application 50% in May and 50% in September, when an average yield of 1658 lb dry cacao per acre per annum was obtained for five years. As was found when the fertilisers were all applied at one time, yields from shaded wide spaced cacao were smaller. Splitting the application of potash fertiliser caused a considerable increase in yield so that the optimum dressing was P- and K- fertilisers at level R_2, when yields of over 1300 lb dry cacao per acre per annum were obtained.

In view of the above results fertilisers are now applied in our experiments as a split dose. One year's yields are available from applying fertilisers at the lowest rate studied as a split dose, and these preliminary results are given in Tables III and IV. The value of splitting the application at

THE EFFECT OF K-FERTILISER ON CACAO YIELDS
1954-1959

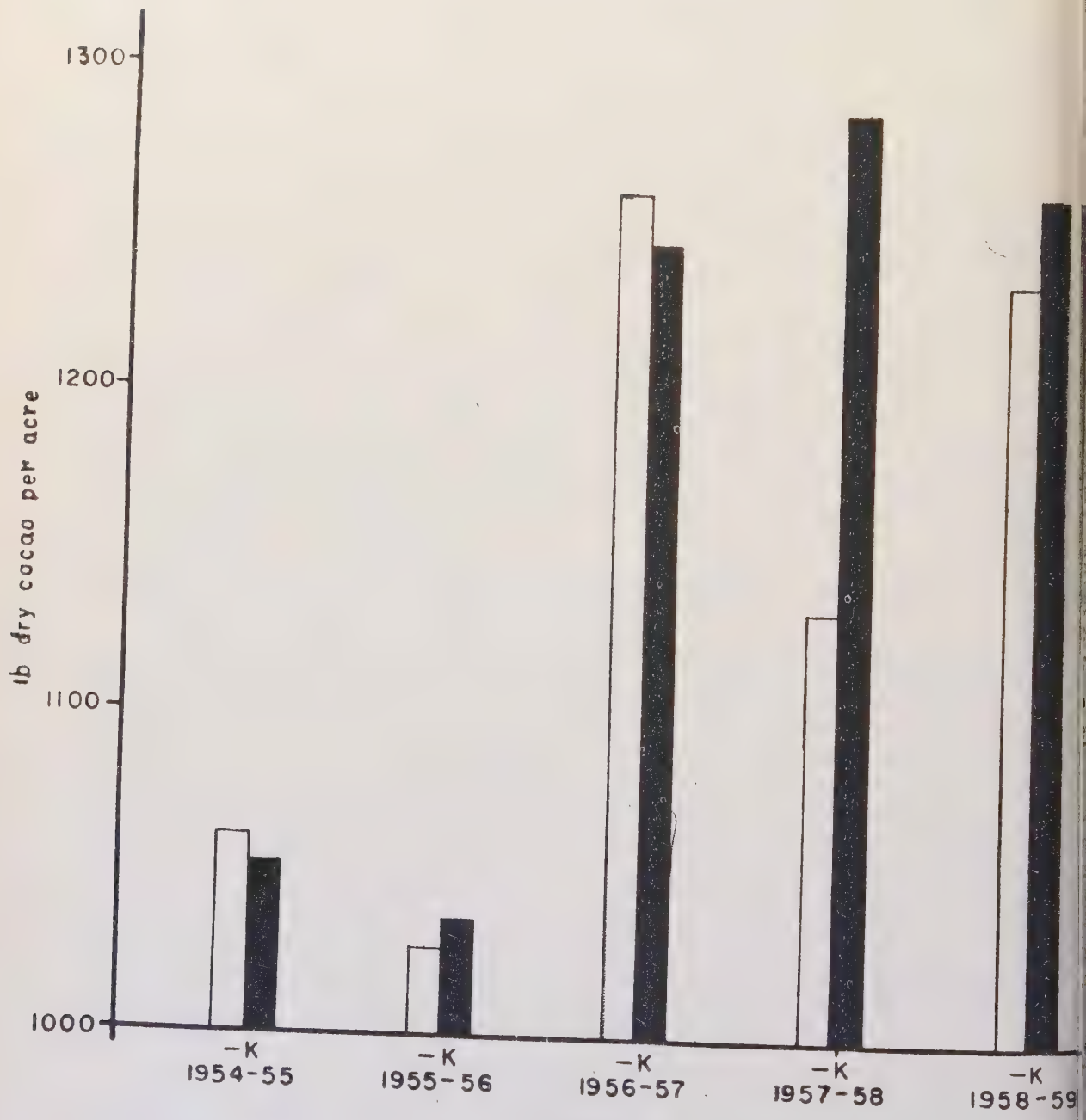

Figure 1

the lowest levels is such that in this crop the most economical yields from unshaded close spaced cacao were from plots receiving N-, P- and K- fertilisers at level R_1, when an average yield of 1855 lb dry cacao per acre were obtained. Shaded wide spaced cacao still yielded best at level R_2, with applications of P- and K- fertilisers.

ations in responses to Fertiliser applications 1954-1959

When results from individual years are studied, there was no nite trend in the yields from unfertilised unshaded close ed plots but plots receiving N- or K- fertiliser alone have ed to give diminishing yields with increasing age, at the est level of application falling to about ½ the control yield he 1958/59 crop (Table III). Plots receiving N,P, and K- ilisers have given high yields throughout the five years with ndency for them to increase still further with time. When iliser applications were split there was little sign of any d in yielding.

The comparable results from shaded wide spaced cacao show that plots have tended to increase their yield from year to year. is possibly due to the natural increase in yield with age, which lower with wide spaced cacao than close spaced cacao. Wide spaced d cacao yielded 880 lb dry cacao per acre (mean from 16 plots, acres) in the 1954-55 crop and 1213 lb dry cacao per acre in the 59 crop, whereas close spaced unshaded cacao yielded 1202 lb dry per acre (mean from 16 plots, 0.85 acres) in 1954-55 and 1293 lb acao per acre in 1958-59.

ffect of potassium fertiliser on yield

It will be apparent from the Tables given that potash fertiliser ontributed the least to yield increments. However the potential tance of potash fertiliser is illustrated in Figure I. There was ked reduction in yield from plots not receiving K- fertiliser in 58 crop, which did not occur in K- treated plots. The yields in e I were the mean from 80 plots (4.23 acres) in each case. The ts illustrated were less marked in shaded plots than those ving N- fertiliser.

ffects of shade and spacing on cacao yields

It is difficult to separate the individual effects of shade and ng and to distinguish between the effects of shade and fertilisers rticular N- fertiliser. A study of Table I shows that under d conditions higher yields were obtained from the closer spacing esponses to fertiliser were small irrespective of the spacing.

In the absence of shade and fertilisers cacao gave relatively poor yields, but the responses to fertilisers, especially N-fertiliser, were large particularly in wide spaced plots. Freeman (1929) studying seedling cacao, came to the conclusion that with spacings 12' x 12' or larger the greatest crop per acre was reaped from the closer spacing (12' x 12') up to the 10th year of the field, and after that the wider spacings either approached or surpassed it. After the 11th year, an increase in spacing was associated with an increase in crop per tree. Our experiments with clonal cacao are now in their 11th year, and, to date, wide spaced cacao (12' x 12') has always yielded more cacao per tree than close spaced cacao (8' x 8') and are now beginning to overtake in yield per acre. A study of the individual years results shows that, although yields from shaded cacao were slightly smaller than from unshaded cacao, any climatic effect such as probably caused the drop in yield in the 1957-58 crop mentioned above, has a much smaller effect on shaded cacao than unshaded cacao. From this it may assumed that where adverse climatic effects or soil conditions are to be expected it will be necessary to sacrifice some fertiliser response and protect the cacao by a certain amount of shade. The extent of the shade will depend on the individual circumstances. This lesson was learned the hard way in Trinidad when clonal cacao was first generally issued and planters in their enthusiasm cut out all shade, resulting in severe reductions from the expected yields especially in areas where soil and/or climatic conditions were adverse.

Type of shade tree

A disease of immortelle, first identified in 1906, has, in recent years, become of great importance in Trinidad, so intensifying the search for alternative shade trees for cacao. Lists of possible trees have been made by many authors since at least 1900, but so far as Trinidad is concerned no tree has been so widely accepted as the Mountain Immortelle, Erythrina poeppigiana. Most of the alternative trees suggested have been legumes, some of which have been accepted in other countries. The marked superiority of the Immortelle is well demonstrated in Table V where yields from ICS 1 grown under 4 different shade trees, two legumes and two non-legumes, over five years are listed.

Soil amendment and cultivations

For consideration under this heading come the following:

1. Mulches
2. Trenching
3. Forking and ploughing

ıing

The application of mulches to cacao has been practised since
·e 1900, and its main effects can be summarised as (a) keeps
weeds; (b) prevents evaporation, and keeps the ground moist;
urnishes suitable manure in gradual supplies and (d) attracts
ı-worms to the surface, and causes them to cut numerous burrows,
ı aerate and cultivate the soil. Wherever cacao is grown it has
found that mulching with cut grasses, weeds or tree loppings as
ıe case of gliricidia shade causes a large increase in yield of
). At River Estate cut grass mulch, consisting mainly of grasses
vith some weeds and small woody plants, has been applied to sha-
:acao spaced 12' x 12' at a rate of 24 tons per acre per year
.ed in two equal doses. Analyses for N, P and K were done on
sample and the equivalent amount of fertiliser to these analy-
:alculated. From 15 such applications it is calculated that
ı mulch at 24 tons per acre per year adds the equivalent of 722
mmonium sulphate, 158 lb double superphosphate, and 366 lb po-
.um chloride per acre per annum. The mean yield from plots
:ed with mulch for 5 years was 1434 lb dry cacao per acre.
other plots receiving the equivalent amounts of fertiliser the
yield over the same period was 1138 lb per acre, similar to
expected from the results quoted in Tables I and II. It is
efore apparent that mulch applications give higher yields than
l be expected from N, P and K contents of the mulch. From the
)mic point of view however a 300 lb dry cacao per acre increase
)t pay for the costs of growing and applying mulch, which is of
)rder of $200 per acre at present costs. In addition it has
calculated that approximately an acre of reasonably good land
equired to grow sufficient grass to mulch at the rate of 24
per acre, which is a wasteful way of cultivating cacao. An
rnative method would be to use a 'low' grade mulch such as saw-
or bagasse to obtain the physical effects of the mulch and ad-
fertiliser to it. As yet our experiments to study this matter
)t give a clearcut answer, but results to date suggest that si-
r yields could be obtained, and may well be profitable.

:hing

The practice of digging trenches and burying mulch and pen
re was started at River Estate in 1922 and yield increases of
150 lb dry cacao per acre were claimed. More recent experi-
s on clonal cacao have supported these results, but similar or
er yields have been obtained by fertilisers without the rather
r costs of digging the trenches.

Forking and ploughing

The system of forking in pen manure has been extensively used in the past in Grenada. It is apparent that with the soil conditions at River Estate cultivations, by hand forking or light ploughing, do not cause an immediate increase in yields. In fact the reverse seems to be the case, cultivation in any form has reduced yields. It is possible however that, whereas annual cultivations are deleterious cultivations at two or more years intervals may be useful, a matter which will be studied in our experiments at River Estate in the next few years.

The effect of cultural practices on cacao diseases

The two main diseases affecting the cacao at River Estate are Witches' Broom (Marasmius perniciosus) and Black Pod (Phytophthora palmivora). Witches' Broom is most prevalent in wetter areas in Trinidad and at times of heavy rainfall and is therefore best controlled by the methods outlined by Holliday or by using resistant strains of cacao, a matter which is outside the scope of this paper.

The average loss from disease in the fertiliser experiment has been approximately 10% of the total pods brought to maturity. A year of heavy loss from disease was 1955-56, associated with a high rainfall towards the end of 1955. An analysis of losses in that year showed that witches broom losses were lower in shaded and/or close spaced, being 15.6% in wide spaced unshaded plots falling to 12.7% in shaded close spaced plots. In unshaded plots N-fertiliser had no effect on the losses, but P- and particularly K- fertilisers reduced losses from 18.2% in the absence of either fertiliser to 12.9% in the presence of both fertilisers. In shaded plots fertilisers had very little effect. When results of black pod losses were considered for this crop, losses were lower from close spaced plots but higher in shaded plots. The losses were much smaller than those from witches broom ranging from 2.4% in wide spaced shaded plots to 1.4% in close spaced unshaded plots. Fertilisers had only slight effects on these losses, N-, P- and K- fertilisers reducing then in shaded plots. In the absence of shade P- fertiliser gave a slight increase in the loss, but K- fertiliser still caused a decrease.

The use of River Estate results in other areas

The experiments at River Estate were designed to answer fundamental problems in the cultivation of cacao, and not only or even primarily to determine the means whereby cacao can be profitably cultivated in the Estate or in Trinidad, although such means should become apparent from them. The late Dr F Pound once wrote 'it is

oming more evident as we progress with fertiliser experiments t the whole success of fertilisers depends on the health, vi- ity, and inherent capacity to yield of trees to which they are lied being reasonably good". This statement is amply illustra- by results in this paper where good responses of up to 50% e been obtained from cacao which is already giving yields which ld be most acceptable by almost any cacao planter. Earlier ex- iments by Dr. Pound at River Estate, with one exception, that of response to K-fertiliser, gave similar results to those later ained with clonal cacao. However, in his experiments, owing to ge tree to tree variations, very big increases in yield were essary to enable the results to become significant. These ear- r experiments were done with seedling cacao, usually 20 - 30 rs old. The recent experiments with clonalcacao up to 10 years have been able to establish the significance of earlier results underline the importance of maintaining a balanced nutrition the tree. The optimum cultural practices for cacao in other as can only be derived from our results when all factors influ- ing the growth of cacao are taken into consideration. Thus it ld be disastrous to plant cacao without shade on a soil which inherently incapable of maintaining the high level of available ients essential for cacao in high light intensities. It may be that on heavier soils than at River Estate, the very high ds obtained there are not reproducible without careful atten- to such factors as drainage, water supplies and aeration h are not of prime importance at River Estate. These factors being studied in experiments being planted on the Sub-station as Hermanas where the soil is a heavy clay. At all times it be remembered that adequate responses to any cultural prac- can only be expected when the standard of management is high.

Many problems still have to be solved before detailed recom- lations can be made from our experiments for other areas. Some hese are being actively studied and include the relationships een soil aeration and root growth, leaf and bark mineral con- and yield, soil moisture relationships, and methods of weed rol, especially in the earlier years of the life of the tree. iew of the larger early yields from closer spaced cacao, the ibility of progressively thinning a close planted field when r spaced cacao is expected to outyield closer spaced cacao also be considered. At all times the increasing costs of la- makes it essential that the possibility of mechanising and nsifying cacao culture must be explored.

Table 1 Mean yield (lb dry cacao per acre per annum over 5 years from plots with different combinations of shade and spacing, receiving fertiliser in May of each year

		0	N	P	NP	K	NK	PK	N
Unshaded close spaced	R_1+		1334	1162	1425	806	1358	1198	15
(8'x8')	R_2+	1162**	1172	1324	1393	1130	1190	1301	15
	R_3+		896	1045	1549	768	1219	1137	15
Shaded wide spaced	R_1+		998	1093	1016	991	1051	1055	10
(12'x12')	R_2+	899**	1063	1108	1048	1000	1000	915	10
	R_3+		946	1035	1122	997	1003	933	11
Shaded close spaced	R_1+	1062**	1194	1197	1218	1068	1133	1312	12
Unshaded wide spaced	R_1+	757**	1221	1022	1396	815	1427	987	12

Table 2 Mean yield (lb dry cacao per acre per annum over 5 year from plots with different combinations of shade and spacing, receiving fertiliser in May (50%) and September (5 of each year. (For explanation of symbols see footnote)

		0	N	P	NP	K	NK	PK	N
Unshaded close spaced	R_2+		1433	1205	1551	1134	1386	1331	16
	R_3+	1162**	1247	1364	1399	1298	1273	1334	14
Shaded wide spaced	R_2+		991	1210	1094	1081	1003	1350	12
	R_3+	899**	1014	965	1099	897	1129	1310	11

able 3 Mean yield (lb dry cacao per acre) 1958-59 crop from close spaced cacao

pplications in May only		O	N	P	NP	K	NK	PK	NPK
ıshaded cacao	R_2		1155	1460	1365	1320	1127	1414	1845
	R_3	1136*	667	1188	1551	445	1272	1302	1977
pplications in May d September									
shaded cacao	R_1		1431	1176	1533	808	1333	1072	1855
	R_2	1136*	1376	1257	1666	1195	1520	1439	1691
	R_3		1204	1335	1451	1219	1275	1284	1521
aded cacao	R_1	1190**	1410	1368	1370	1131	1417	1611	1400

ble 4 Mean yields (lb dry cacao per acre) 1958-59 crop, from wide spaced cacao

plications in May only		O	N	P	NP	K	NK	PK	NPK
ıded cacao	R_2		1212	1220	1246	982	1129	1174	1067
	R_3	1064*	1124	1363	1221	1093	906	997	1259
plications in May l September									
ded cacao	R_1		1155	1375	1183	1203	1194	1212	1317
	R_2	1064*	1200	1289	1275	1189	1132	1556	1262
	R_3		1216	1142	1167	996	1256	1479	1173
haded cacao	R_1	798**	1369	951	1684	819	1465	1266	1608

Symbols: R_1- Fertiliser applied at the rate of 450lb S/A; 150 lb double superphosphate and 300lb Potassium Chloride per acre per annum.

R_2+ Fertiliser applied at twice the above rate.

R_3+ Fertiliser applied at three times the above rate.

1162* Mean yield from 12 plots, i.e. 0.63 acres.

1062** Mean yield from 4 plots, i.e. 0.21 acres.

All other yields are the mean from 2 plots, i.e. 0.11 acres.

Table 5 Yields from ICS 1 grown under various shade trees 1954-59. lb dry cacao per acre. (Cacao planted in 1950)

Fertiliser	Non-legume trees		Legume trees	
	Theobroma bicolor	Tabebuia pentaphylla	Peltophorum ferruginium	Erythrina poeppigiana
PK	1009	568	904	1548
NPK	1115	700	996	1625
Mean Yields	1062	634	950	1587

SUMMARY

This paper brings together the main results of field experiments at River Estate, Trinidad, on the response of cacao to fertilisers, organic manures, mulching and soil cultivations, and the interactions between these factors and shade and spacing.

Considerable yield response has been obtained from N, P and K fertilisers and the results are much affected by whether the fertilisers are applied singly or in combination, once or twice a year, and by the shade and spacing conditions. Cacao growing under shade of Erythrina poeppigiana gave higher yields than did cacao under three other shade trees. Grass mulches markedly increased yields, and these were higher than those from plots receiving equivalent quantities of chemical fertilisers, but the cost renders mulches uneconomic. Yearly forking and ploughing have reduced yields; long intervals are to be studied.

The extension of the results from River Estate to other areas is discussed, and some of the detailed problems currently under study are reviewed.

RESUMEN

Este trabajo recoge los resultados principales de los experi-
tos de campo realizados en River Estate, Trinidad, sobre la
cción de cacao a fertilizantes, abonos orgánicos, coberturas o
lching" y arados de suelo, y la interacción de estos factores
sombrio y espacio.

Se han obtenido altos rendimientos con fertilizantes N, P y
y existe una gran diferencia en los resultados que dependen de
se hacen aplicaciones únicas o combinadas de los distintos fer-
izantes, una o dos veces por año y de las condiciones de sombrio
spacio. El cacao que crece bajo la sombra del Erythrina poe-
giana dió rendimientos más altos que el cacao bajo otros árboles
sombra. Coberturas de pasto tuvieron un efecto definitivamente
orable, y los rendimientos fueron mayores que en el caso de
celas tratadas con cantidades equivalentes de fertilizantes quí-
os, pero el alto costo de las coberturas hace que este sistema
poco economico. El rastrilleo o arado anual disminuye los rendi-
tos; se están estudiando intervalos más largos.

Se discute la extensión de los resultados de River Estate y se
una revision detallada de algunos de los problemas que actual-
e se estan estudiando.

SUMMARY OF DISCUSSION

Ing. C. Navarrete (Venezuela)

What is the potassium status of the soil at River Estate and consumption of K as shown by leaf analysis. Is luxury consumption occurring?

Dr. G.K. Maliphant (ICTA)

The available and exchangeable potassium in the soil at River Estate is low, but the total reserves of potash are high. Potassium fertiliser applications caused an increase in leaf - K levels but as no yield responses were found it is suggested that this represents a luxury consumption.

Dr. D.R. Glendinning (WACRI)

A very great deal of work of this nature has been done at WACRI in Ghana during the last four years or so. These comments are intended simply to indicate the type of work that is being done and at most to give a very approximate idea of the results, as I am not sufficiently closely connected with the work to be able to give details. More information could be obtained from our quarterly and annual reports, and other publications.

The original shade and fertilizer experiment was performed on a uniform plot of Amelonado seedling cocoa, which was under shade and about 10 years old at the commencement of the experiment. The spacing is 8 ft. by 8 ft. The four treatments are:-

Shade without fertilizer (equivalent to a "control")
Shade with fertilizer
Shade removed, without fertilizer
Shade removed, with fertilizer.

The trial is replicated, each treatment covering a total area of over an acre.

The "control" has given yields up to 900 lbs. dry cocoa per acre, and the best treatment (shade removed, with fertilizer), about 3,100 lbs. per annum in the best year to date. I should mention though that we have made no recommendation for removal of shade.

Further to this trial, a similar experiment has been set up Amazon cocoa at Bunso, a Division of Agriculture station in na, and plantings have been or are being made for equivalent g-term experiments at WACRI on Amazon cocoa (30 acres) and the hybrids (20 acres).

A large number of fertilizer experiments have been set up on ision of Agriculture stations and on farmers' cocoa in Ghana. the considerations relating to the design of these trials, see WACRI Technical Bulletin by R.K. Cunningham. Two years pre- ording was usually found necessary, and a high replication of ts of an adequate size. Significant responses are being ob- ned, and we find that economic responses can often be obtained vided the cocoa is in reasonable condition to start with. Most ponses are to phosphorus, and some to nitrogen, though I think nly or only when phosphorus is also added. Potassium seems atively unimportant.

Sand and water culture studies have been carried out by elvie and Hurd, and an extension of this work is now being com- ced. A large greenhouse is being built at a cost of some thou- ds of pounds.

Radioisotopes have been used to study the uptake of nutrients. pectographic laboratory is in operation for the study of soil plant specimens, aimed mainly at trace element studies. Very d growth of seedlings freed from weed competition has been ob- ned, and studies have been made of the deterioration of exposed l, and of the use of cover crops and mulches. An irrigation eriment is in progress in which 1/3 of the shade and manurial al (described above) is being maintained above a certain minimum l moisture status throughout the year.

This account does not fully embrace the work that has been e or is in progress at WACRI which has bearing on this morning's cussions, but will serve to give some idea of its scope.

G.K. Maliphant (ICTA)

I agree with Mr. Glendinning on the importance of plot size in tilizer experiments. The highest yield recorded at River Estate m ICS 1 were of the order of 2,400 lbs. dry cacao per acre and t considerable interest is shown in the 3,000 lb. per acre ob- ned at WACRI. WACRI are to be complimented on their magnificent ults. I have been in correspondence with Dr. Cunningham of WACRI so far failed to elucidate the problem of how such high yields e obtained from Amelonado cacao.

In Trinidad we use potassium chloride fertilizer and not potassium sulphate as is used at WACRI. The leaf scorch sometimes claimed to be caused by excessive chloride applications has occurred, but in a survey of the fertilizer experiment it was found that scorch was more closely associated with intense shade conditions than with any fertilizer application. A sand culture experiment at ICTA had shown that scorch was more associated with either a very humid or a very dry climate than either of the treatments applied, such as excess chloride, excess salt, excess sulphate or trace potassium. It is refreshing to hear of positive results being obtained from fertilizer applications, after so many years of inconclusive results which have led to opinions in some quarters that cacao never responds.

The success of workers at WACRI in growing cacao without even temporary shade is to be welcomed. An experiment at the Las Hermanas sub-station is being planted in 1960 to study the effects of weed control as well as irrigation on cacao growth.

Mr. B. Topper (Jamaica)

In 1957 at Palmira Dr. Maliphant referred to the correlation between girth and yield; can he add any information to this?

Dr. G.K. Maliphant (ICTA)

Mr. Topper is referring to a paper presented at the Colombia Conference and subsequently published in "Tropical Agriculture" and "Nature". In the Report on Cacao Research for 1957/8 which has recently become available in Trinidad, it was shown that correlations previously reported disappeared with age as the poorer trees caught up with the better trees.

Mr. G. Havord (IAIAS)

May I make a plea for many more fertilizer experiments under different conditions of soil and climate? We have heard of sizeable responses from the experiments at River Estate and at WACRI, but we shall hear on Thursday of other experiments in Trinidad, on different soils where responses have been negligible. In Costa Rica a factorial NPK experiment with and without shade on young clonal cacao has been in progress now for two years. It is planted on a soil of good structure and drainage, and of high fertility. There have been no yield responses so far. The rates of fertiliser application are similar to the "standard" treatments at River Estate. We are now considerably increasing the quantities supplied.

ne other hand we have obtained small but distinct responses to application from 40-year old unshaded cacao already yielding t 10 lb. of dry cacao per tree. Unfortunately we cannot multiply these yields up to yields per acre, as we are dealing with ld field with about a 60% stand.

L.L. de Verteuil (Chairman)

The theory of high yields with no shade and fertilizer is a very active one. We have just heard about the very impressive yields ver 3,000 lbs. of dry cocoa per acre in West Africa. There is ver another side to this picture and before closing, I should like elate our experiences in this connection at the Central Experiment ion here in Trinidad.

An experiment testing shade versus no shade together with close wide spacing and the usual N.P.K. treatments was planted in 1952. ould mention that the soil type was Cunupia Clay-loam, a rather r soil with impeded drainage but quite typical of large cocoa ng areas in Trinidad. In 1959 the temporary shade was removed, hat until that year, the shade factor was not operative. Unusu- dry weather conditions followed. To cut a sad story short, the ade treatment suffered considerable losses; in fact these areas l be written off as a complete loss. The shaded plots ranged 52 to 75% survival, with the exception of one block which also ered severe losses, and it is interesting to note that it had two aded blocks on the side of the prevailing wind. This introduced additional factor of exposure.

This story is not intended in any way to cast doubts on the impressive results obtained in West Africa; nor even can it prove that a cannot be successfully grown in Trinidad without shade, but what oes emphasise is the very limited application of experiments.

I have observed that authors seldom, if ever, make mention of the conments where their experiments are conducted. One might well what are we shading from? What are we shading with? I think per- we are too apt to oversimplify the question of shade or no shade erms of light effects; I think we should remember that shade s have roots.

In conclusion, I would make a plea that environmental conditions r which experiments of this nature are conducted should be clear- tated, for without this information it is impossible to evaluate results.

Finally this problem emphasises the need for much more informa- concerning the cocoa tree and its environments. I think at stage of our knowledge we should consult the laboratory rather the field.

RECHERCHES SUR LA NUTRITION MINERALE ET LA FERTILISATION DU CACAOYER, ET ETUDE DES SOLS A CACAOYERS DE COTE D'IVOIRE

A. Loue,[*] G. Verlière,[*] Le Lay[**]

Les études sur la nutrition minérale, la fertilisation des cacaoyers, ainsi que sur les sols a cacaoyers de Côte d'Ivoire ont été abordées dans leur ensemble a partir de 1959, dans le cadre des activités de l'Institut Français du Café et du Cacao.

Jusqu'ici quelques études isolées avaient été poursuivies sur des sols de plantations.

D'autre part, le probleme de l'échantillonnage du cacaoyer en vue de l'utilisation du diagnostic foliaire, pour l'étude de la nutrition et de la fertilisation, avait été abordé (Bulletin 11 Centre Recherches Bingerville 1955).

Enfin, des recherches de base avaient été poursuivies en Côte d'Ivoire par le Professeur LEMEE, relatives a l'éco-physiologie du cacaoyer (Revue générale de Botanique Tome 63 - 1956).

Le programme de recherches de l'I.F.C.C. reprend ces principaux sujets sous forme d'une étude générale des conditions écologiques et de l'amélioration des rendements par action sur le milieu

I. ETUDE DES CARENCES ET DES DEFICIENCES MINERALES CHEZ LE CACAOYER

1. Les carences minérales obtenues expérimentalement

Il est apparu nécessaire d'accompagner les études au champ (diagnostic foliaire de parcelles d'essais d'engrais) d'une étud en milieux artificiels de la zone nutritive précise des carences et déficiences minérales accusées.

Les principaux buts de cette étude sont:

a) Etudier, enregistrer, décrire les symptômes visuels correspondant à chaque carence;

b) Essayer d'associer les teneurs des organes malades en les éléments étudiés et la gravité des troubles constatés

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[*] Physiochimistes

[**] Pédologue

Centre de Recherches de l'Institut Français du Café, du Cacao, Côte d'Ivoire

c) Permettre des reconnaissances éventuelles de cas de déficiences en plantations;

d) Apprécier la validité de l'extension en matière de fumure du cacaoyer par l'examen de troubles foliaires éventuels en plantations.

dispositif expérimental

La méthode est celle des solutions nutritives; les graines type Amelonado ont été semées dans du sable stérile; 50 jours rès le semis, les jeunes plantules ont été mises dans des fla- ns en verre de 1 litre, à raison de quatre plants par flacon. cours des trois premiers mois de l'essai les solutions furent angées toutes les trois semaines et ensuite toutes les deux naines. L'ensemble de l'essai comportait 160 flacons corres- ndant à 640 cacaoyers selon la répartition suivante:

Solution complete 15 pots - sans azote 15 pots - sans souf- 15 pots - sans phosphore 15 pots - sans potassium 15 pots - ns calcium 40 pots - sans magnésium 15 pots - sans fer 10 pots - ns manganèse 10 pots - sans bore 10 pots.

sultats obtenus

Les symptômes de chaque carence ont été obtenus avec une ande netteté; les mesures portant sur la hauteur moyenne des ges ont montré l'évolution suivante:

a) Un groupe a sa croissance très affectée des le 3ème mois de l'essai: carences en azote, soufre, calcium.

b) Un groupe voit la croissance ralentie entre le 3eme et le 5ème mois de l'essai. Il comprend le potassium, le magnésium, le fer, le manganese, le bore; la carence magnésienne est la plus sévère de ce groupe.

c) Un groupe a une croissance normale (solutions complètes et sans phosphore). La croissance des plants sans phosphore n'a été affectée que vers le 9eme mois de l'essais.

La composition chimique des plants vis à vis de N, S, P, Ca, Mg et Fe, Mn, B a été suivie au cours de l'évolution s maladies par des prélèvements.

Les divergences des résultats obtenus antérieurement par ans, Murray, Maskell d'une part et Alvim d'autre part, con- rnant principalement les cations ont été élucidées.

La publication relative à ce travail comportera 28 anches en noir et blanc et 20 planches en couleurs.

2. Les déficiences minérales obtenues expérimentalement

Une seconde expérience porte sur un ensemble de 40 seaux en polyéthylène qui contiennent chacun douze litres de solutions nutritives. L'essai porte seulement sur les éléments majeurs N S P - K Ca Mg et vise à l'obtention de symptômes moins graves grâce à l'introduction de petites doses de chaque élément étudié N_1 N_2N_3 Mg_1 Mg_2 Mg_3.

3. Les déficiences minérales reconnues en Côte d'Ivoire

En même temps, des études en plantations ont porté sur la recherche de cas de déficiences, avec prélèvements d'échantillons foliaires correspondants.

Ces études concernent surtout les éléments majeurs N P K Ca Mg. La déficience en zinc a été aussi étudiée de cette façon.

ETUDE DE LA NUTRITION MINERALE ET DE LA FERTILISATION DU CACAOYER

La méthode utilisée est celle du contrôle biochimique (diagnostic foliaire) de parcelles d'essais d'engrais implantées sur des stations correspondant aux principaux types de sols et de climats de la région cacaoyère de Côte d'Ivoire.

La date récente du début de ces études n'a permis que la mise en place d'un nombre restreint d'essais. C'est ainsi que l'étude de certaines questions ne commencera qu'au cours de l'année 1960 par exemple: relation entre fumure et densité de l'ombrage, mode de placement des engrais, nature des engrais azotés et phosphatés.
Nous ne considererons ici que les essais déjà mis en place.

A. NATURE ET DESCRIPTION DES ESSAIS

L'on distingue les essais de base comprenant un certain nombre de répétitions avec divers éléments fertilisants et les essais multilocaux, où seule est testée une formule NPK, effectués en plantations africaines à titre de prévulgarisation.

1. Essais de base

Ils occupent actuellement une superficie de 14 ha répartis dans les trois grandes zônes écologiques de Côte d'Ivoire.

Essais de Bingerville

Ils sont destinés à étudier les exigences du cacoyer en Basse Côte d'Ivoire dans la région des sables tertiaires avec une pluviométrie annuelle moyenne de 1900 mm.

Il s'agit d'arbres agés de 35 à 40 ans sous ombrage naturel de palmiers; ils sont plantés en quinconce; les intervalles sur une ligne sont de 3 mètres et de 3 mètres également entre les lignes.

Deux dispositifs sont en place à Bingerville:

Un essai général d'engrais de 5 ha comprenant 5 blocs de 10 parcelles chacun. Les engrais utilisés sont le sulfate d'ammoniaque (N), le phosphate bicalcique (P), le sulfate de potasse (K), le bicarbonate de potasse (K') et le chlorure de potasse (K"). Les combinaisons suivantes ont été réalisées: N P K K' K" NP KN PK NPK et T (Témoin).

La comparaison des formes d'engrais potassiques a été incorporée à cet essai général, les sols de cette région étant carencés en potasse.

L'engrais est épandu en deux fois aux doses suivantes (en grammes par arbre):

	N	P	K	K'	K"
Fin Avril	200	75	100	90	110
Mi Septembre	150	75	100	90	110

Il est légèrement enterré sur des circonférences situées à 1 metre du tronc et il est ensuite recouvert de feuilles mortes. Ce mode d'épandage est utilisé pour tous les essais.

Un essai comparatif d'engrais NPK réparti en 5 blocs de 6 parcelles chacun et occupant une superficie de 3 hectares.

Cinq formules sont appliquées et un témoin ne reçoit aucune fumure. L'azote est apporté sous forme de sulfate d'ammoniaque, le phosphore sous forme de phosphate bicalcique et le potassium sous forme de sulfate de potasse. L'épandage se fait en deux fois aux mêmes dates que pour l'essai précédent. Les doses utilisées, en grammes d'engrais par arbre, sont de:

		Sulfate d'ammoniaque	Phosphate bicalcique	Sulfate de Potasse
T		0	0	0
A	Avril	100	37,5	50
	Septembre	75	37,5	50
B	Avril	200	75	100
	Septembre	150	75	100
C	Avril	300	112,5	150
	Septembre	225	112,5	150
D	Avril	200	112,5	100
	Septembre	150	112,5	100
E	Avril	200	75	150
	Septembre	150	75	150

Les formules A, B et C correspondent à un même équilibre N/P/K et constituent un essai de doses (B = 2A, C = 3A). La formule D est plus riche en P alors que E est riche en potasse. La formule B correspond a la formule NPK de l'essai général décrit au paragraphe précédent.

La densité des palmiers est fortement hétérogène et atteignait sur certaines parcelles 210 arbres/ha. Les arbres en surnombre ont été empoisonnés à l'aide d'une solution d'arsénite de soude (1000 g arsénite + 1 litre d'eau) à raison de 80 cc par arbre versés dans deux trous de 20 cm de profondeur percés à 1 mètre du sol environ. L'on s'est efforcé, dans la mesure du possible, de ne laisser subsister que des arbres dont les palmes ne se recouvriraient pas, sans créer pour autant des trous de lumière.

b) Essais de Gagnoa

Implanté sur une station du Service de l'Agriculture, cet essai couvre une superficie de 3 hectares, en région de sol granitique recevant une pluviométrie annuelle de 1400 mm en moyenne. Deux hectares ont été plantés en 1953 et le troisième en 1954.

L'ombrage est l'ombrage forestier naturel pour 2 hectares où la plantation a été faite en semis direct. En ce qui concerne le troisième hectare, l'ombrage na-

turel a été abattu et remplacé par des Pithecolobium. La plantation a été faite en paniers. En attendant que les Pithecolobium puissent fournir un ombrage suffisant, celui-ci a été assuré pendant les quatre premières années par des bananiers.

Les arbres ont reçu en 1955, 125 g. de sulfate d'ammoniaque, 50 g. de phosphate bicalcique et 50 g. de sulfate de potasse. A partir de 1956 l'épandage se fait en deux fois, début Avril et mi Septembre. Les doses de 1956 furent en g./pieds de:

	Avril	Septembre
Sulfate d'ammoniaque	125	125
Phosphate bicalcique	100	0
Sulfate de potasse	50	50

A partir de 1957, elles ont été faites a:

	Avril	Septembre
Sulfate d'ammoniaque	200	175
Phosphate bicalcique	150	0
Sulfate de potasse	75	75

Chaque hectare est divisé en deux blocs de 8 parcelles, chacun comprenant les objets suivants: N - P - K - NP - NK - PK - NPK - T.

Essai d'Abengourou

Cet essai est établi chez un planteur africain, dans une région où la pluviométrie est de 1350 mm, mais avec une saison sèche plus marquée en Décembre, Janvier, Février que dans la région de Gagnoa. Il s'agit d'une région de schistes avec des lentilles de granit et l'essai est implanté sur l'une de ces dernières.

Comme à Bingerville, deux essais différents sont en place à Abengourou.

Un essai général d'engrais de 1 ha 50 sous forme de trois blocs de 8 parcelles comprenant les combinaisons suivantes: N P K NP NK PK NPK T. Il a été mis en place en 1954 et les premières applications d'engrais datent de 1956.

Les arbres sont agés de 20 ans et plantés au hasard sans aucun alignement, ce qui crée une certaine hétérogénéité dans la densité de chaque parcelle. L'ombrage est très réduit.

L'épandage est également fait en deux fois, fin Mars et fin Septembre. L'engrais est amené aux doses suivantes (en gr./arbre):

	Mars	Septembre
Sulfate d'ammoniaque	200	175
Phosphate bicalcique	75	75
Sulfate de potasse	100	100

Un essai comparatif d'engrais NPK de 1 ha 50 sous forme de carré latin 4 x 4 permettant de comparer 3 formules NPK à un témoin A.

A: témoin

B: formule NPK de l'essai précédent

C: 500 gr. d'engrais complexe granulé 12-15-18 (250 gr. à chaque épandage)

D: 500 gr. d'engrais complexe granulé 10-10-20 (250 gr. à chaque épandage)

Notons qu'un essai général d'engrais est en préparation sur schistes dans la région d'Abengourou; il sera analogue à celui actuellement établi sur granit dans la même région.

2. Champs d'essais multilocaux

En dehors de ces essais de base, il existe un certain nombre de champs d'essais multilocaux répartis de la côte à la limite septentrionale de la zone de culture du cacaoyer. Ils occupent chacun une superficie d'environ 1 hectare divisé en 2 parcelles dont l'une sert de témoin et ne reçoit aucun engrais, alors que l'autre est l'objet d'une fumure complète NPK variable suivant les régions. En plus du rôle qu'ils jouent dans les recherches sur la nutrition minérale ces champs établis dans des plantations africaines ont de plus un but de démonstration et de vulgarisation vis à vis des planteurs.

L'épandage des engrais et le contrôle des récoltes sont faits en collaboration avec le Service de l'Agriculture.

B. ETUDE DE LA NUTRITION PAR LE DIAGNOSTIC FOLIAIRE

Le laboratoire a pu procéder à des prélèvements foliaires à partir de juillet 1959. La méthode retenue est celle qui a été proposée par Loue en 1955 (Bulletin no. 11 du CRA pp. 29-47).

Les essais de Gagnoa et d'Abengourou sont maintenant suivis régulièrement et les prélèvements y sont effectués tous les deux mois; il en est de même pour un certain nombre des essais multilocaux. En ce qui concerne Bingerville, l'on a dû se limiter au contrôle biochimique de certaines parcelles et non de l'ensemble, en raison de la difficulté de récolte des feuilles du fait de la hauteur des arbres.

Au point de vue des analyses chimiques, l'azote est déterminé par la méthode de KJELDAHL, le phosphore par colorimétrie (méthode au molybdate-vanadate), le magnésium, potassium et calcium par photométrie de flamme.

ETUDES SUR LA CROISSANCE DU JEUNE CACAOYER

Elles ont pour but de préciser les besoins du cacaoyer pendant les 18 premiers mois.

Le dispositif expérimental se compose de 50 planches de 185 plants chacune. Les graines ont été semées en carré à 30 cm les unes des autres. Ces planches forment 2 blocs de 5 objets chacun (T - N - P - K - NPK); chaque objet est donc représenté par 5 planches de cacaoyers. Chaque quinzaine sont arrachés 4 plants par planche et sur l'ensemble des 20 plants de chaque objet sont déterminés:

a) Poids et pourcentage de matière sèche des racines, tiges et feuilles;

b) Hauteur des troncs, nombre et dimensions des feuilles;

c) Teneur en NPK, Ca et Mg des racines, tiges et feuilles.

L'engrais sera apporté sous forme de sulfate d'ammoniaque, phosphate bicalcique et sulfate de potasse, lorsque les plantes seront âgées de 6 mois, c'est à dire à la fin du mois d'Avril 1960.

ETUDE DES SOLS A CACAO

Etude physique

Les régions de culture cacaoyère de Côte d'Ivoire s'étendent pour les plus importantes, en deçà de ce qu'il est généralement convenu de considérer comme limite inférieure de pluviométrie nécessaire à cette culture, soit 1500 mm. Certaines des régions productrices ne reçoivent qu'une pluviométrie moyenne de 1200 mm avec des minimum inférieurs à 1000 mm.

Le problème de l'eau revêtant ainsi une importance majeure en matière de nutrition du cacaoyer et risquant dans bien des cas de devenir le facteur limitant, il était indispensable de déterminer le bilan hydrique des sols à cacaoyers.

Il est envisagé de conduire parallèlement des études physiologiques sur le bilan hydrique du cacaoyer, avec l'interaction supplémentaire de la nature du couvert (extension et application agronomique de l'étude citée plus haut du Professeur Lemée).

Un certain nombre de cacaoyères ont été repérées, réparties sur le territoire d'une part suivant la pluviométrie depuis les isohyètes 1100 jusqu'aux régions côtières recevant plus de 2 mètres d'eau; d'autre part en fonction des types de sols que nous pouvons trouver sur les différentes roches mères:

- Sur roche basique: sols argileux à plus de 40% d'argile, à forte capacité d'échange de bases;
- Sur schistes: sols argilo-sableux fins: 40 à 50% de sable fin et argile kaolinitique;
- Sur granit: sols argilo-sableux grossiers à argile kaolinitique et souvent très encombrés de gravillons ferrugineux (jusqu'à 50%).

Les conditions pluviométriques de ces différentes stations sont connues grâce à la présence de pluviomètres et d'appareils enregistreurs (hygromètres et thermomètres) sur les points principaux correspondant aux essais d'engrais de base signalés au Chapitre II.

Sur chacune des parcelles repérées, les profils hydriques sont établis périodiquement en fonction des précipitations.

Durant la saison sèche, les périodes séparant les prélèvements sont plus rapprochées et visent à déterminer le profil hydrique à la fin de la plus longue phase de jours secs consécutifs.

D'autre part, chacun des sols de ces parcelles est caractérisé par une analyse complète comprenant:

- Analyse mécanique;
- Analyses physiques avec courbe de pF, perméabilité, porosité.

Parallèlement à l'établissement des profils hydriques et n relation avec les problèmes d'échantillonnage des observa-ions sont effectuées concernant l'état végétatif des arbres apparition des flush, croissance et taille des feuilles au oment de leur verdissement, chutes des feuilles, floraisons).

tude chimique

Cette étude est menée simultanément avec les analyses de euilles sur les parcelles témoin des essais de base et des ssais multilocaux d'engrais (analyses sol-plante).

En outre, sont étudiés les sols de nombreuses autres lantations intéressantes du point de vue pédologique ou opographique.

Les analyses saisonnières faites sur ces sols ont déjà ait apparaître des différences concernant particulièrement es bases échangeables suivant la date de prélèvement.

Trois points retiennent plus particulièrement notre ttention:

- Phosphore assimilable - Inventaire des principales méthodes - corrélation des résultats de ces méthodes avec les chiffres fournis par l'analyse foliaire.
- Taux de saturation en bases
- Evolution de la matière organique: minéralisation de l'azote.

Ces études doivent permettre de préciser les composants e la fertilité des sols à cacaoyère et de jeter quelque lu-ur sur le problème crucial en Côte d'Ivoire de la replanta-ion de cacaoyers sur d'anciennes cacaoyères ainsi que sur elui de la rationnalisation des extensions de cultures in-ustrielles.

SUMMARY

In 1959, the Institut Français du Café et du Cacao under-ook a comprehensive study dealing with mineral nutrition and ertilization of cacao and cacao soils in Ivory Coast.

Up to that time, some individual studies only had been ndertaken in the field, but the problem of sampling cacao in rder to use the foliar diagnostic method in the study of nu-rition and fertilization had already been investigated, and

basic researches on cacao eco-physiology had been carried out in Ivory Coast.

The research program of IFCC covers these subjects in a comprehensive study of ecological conditions and the improvement of yield by means of manipulating environmental factors.

RESUME

Les études sur la nutrition minérale, la fertilisation des cacaoyers, ainsi que sur les sols à cacaoyer en Côte d'Ivoire ont été abordées à partir de 1959 dans le cadre des activités de l'Institut Français du Café et du Cacao.

Jusqu'ici quelques études isolées avaient été poursuivies sur des sols des plantations. D'autre part, le problème de l'échantillonage du cacaoyer en vue de l'utilisation du diagnostic foliaire pour l'étude de la nutrition et de la fertilisation avait été abordé, ainsi que des recherches de base relatives à l'éco-physiologie du cacaoyer en Côte d'Ivoire.

Le programme de recherches de l'IFCC reprend ces principaux sujets sous forme d'une étude générale des conditions écologiques et de l'amélioration des rendements par action sur le milieu.

RESUMEN

En 1959, el Institut Français de Café et du Cacao emprendió un estudio básico sobre nutrición mineral y fertilización en cacao y sobre suelos de cacao en la Costa de Marfil.

Hasta esta fecha se habían hecho únicamente estudios aislados en el campo. Sin embargo, se habian hecho trabajos sobre la aplicación del método de diagnosis foliar al problema de nutrición y fertilización. También llevó acabo investigaciones básicas sobre la eco-fisiología del cacao en la Costa de Marfil.

El programa de investigación del IFCC abarca estos tópicos en un estudio completo de las condiciones ambientales y del mejoramiento de rendimentos mediante el manejo adecuado de los factores ambientales.

EFFECT OF THREE NITROGEN SOURCES AND TWO LIGHT INTENSITIES ON THE NITROGEN CONSTITUENTS OF COCOA SEEDLING LEAVES OF THREE DIFFERENT AGES

M. Machicado and D. Boynton*

INTRODUCTION

Several investigators in Trinidad and at Turrialba, Costa Rica, e studied the different effects of environmental conditions, and ticularly the influence of the light and nitrogen sources, on the wth of the cacao trees and the content of principal elements in cacao leaves. (1,3,6,7,8,9)

The content of soluble nitrogen compounds in cacao beans has n reported by Forsyth (5). Cain (2) has reported preliminary ob- vations on the soluble nitrogen compounds in cacao leaves. Fen- (4) has also studied the constituents of insoluble nitrogen com- nds, ammonia-, amide- and amino-nitrogen in cacao leaves of vari- ages of trees grown in the field under varying light intensities.

The objective of this work is to determine the soluble nitrogen pounds in leaves of cacao seedlings at three different ages, grown er three different nitrogen sources and two light intensities.

MATERIALS AND METHODS

Greenhouse experiments were conducted at Cornell University which cacao seedlings were grown in sand cultures using for mi- al nutrition a modification of Hoagland's solution. The seedling nts were obtained from the Plant Introduction Station, Glenn Dale, yland. They were supplied with three different sources of nitro- and subjected to two light intensities. The sources of nitrogen e as follows: a) ammonia, b) nitrate, and c) urea. The amounts nitrogen and the other essential elements were the same as in mal Hoagland's solution. Only the source of nitrogen was chang- in the different treatments. The sources were as follows: for onia - $(NH_4)_2 SO_4$, for nitrate - KNO_3, for urea - $(NH_2)_2 CO$. cc. of nutrient solution was applied every two days and it was owed to percolate through the sand.

omology Department, Cornell University, Ithaca, New York

During the experiment, measurements of growth and dates of each flushing were noted. At the end of the experiment, samples were taken of 30-day, 60-day and 90-day old leaves. The samples were immediately frozen in dry ice. Later each sample was lyphillized and then ground to a powder in the Wiley Mill. Sub-samples were taken for chemical analysis. Total nitrogen was determined by the Kjeldahl procedure. Intermediary nitrogen compounds were determined by chromatographic analysis using two-directional paper and phenol-water and butanol-acetic compounds as the solvents. The procedure and the quantitative estimation followed the methods of Thompson and Stew rd (10).

Potassium, calcium and magnesium were determined by flame photometer, using the Beckman Model B with photomultiplier and hydrogen flame. Phosphorus determination was carried out colorimetrically.

RESULTS

The average growth and dry weight of leaves, roots and stems of cacao seedlings in each treatment are given in Table 1.

At the end of the experiment there were large differences between plants which received no nitrogen and those of the other treatments. Leaves of plants from the minus nitrogen treatments showed a severe nitrogen deficiency.

The plants under full light had greater dry weight of roots, leaves and stems, than those under half light. There were also similar differences in shoot growth.

Under both light treatments the plants receiving nitrate produced the most dry weight and those receiving ammonia produced the least.

ble 1.

The effects of three nitrogen sources on the growth measurements of cacao seedlings growing in full and half light under greenhouse conditions.

wth Measurements		Half Light			Full light			
		NH_3	NO_3	Urea	NH_4	NO_3	Urea	-N
weight: (gms)	Root	.91	.96	.93	1.32	1.38	1.39	1.15
	Leaves	1.13	1.90	1.69	1.71	3.00	2.86	1.05
	Stem	1.95	1.71	1.36	2.08	2.62	2.08	1.48
al dry weight		3.69	4.59	3.98	5.11	7.10	6.33	3.48
rage shoot length (cms)		30.0	32.2	32.4	34.2	43.8	32.9	26.7

Table 2 summarizes data for total N, K, Ca and Mg in the samples leaves 30, 60, 90-days old, taken at the end of the experiment. was noted that the nitrogen content of the leaves in plants which eived no nitrogen was markedly lower than plants which were sup- ed with either ammonium, nitrate or urea. This result is consis- t in the three different ages of the leaves.

Under both conditions, full and half-light, the nitrogen con- t of the plants was high in the plants supplied with urea, inter- iate in the plants with nitrate and low in the plants with ammo- n.

The effects of leaf age are similar to those reported by many er investigators for other species. In young leaves N, P and K centrations were greatest whereas Ca and Mg concentrations were st. The young leaves from the nitrate treatment also seem some- higher in total N concentration than those from the ammonium atment.

Tables 3, 4 and 5 summarize the data for individual soluble ogen fractions in the leaf samples at 30, 60 and 90 days. The gest leaves were markedly lower in total soluble nitrogen than those 60 and 90 days old. With one exception the sum of solu- nitrogenous fractions was greater in 90 day leaf samples than in lay samples. So far as the totals are concerned no significant erences were evident between samples receiving half light and

those exposed to the full light of the greenhouse. In the totals, the plants having urea as the source of N were consistently higher in soluble N than were the others, with no consistent difference between those receiving NH_3 and those receiving NO_3.

More than half of the nitrogen from the soluble nitrogen compounds identified in each sample was derived from five compounds; glutamic acid, serine, asparagine, arginine, and α-amino butyric acid. Of these, asparagine and arginine appeared to increase most markedly with leaf age, and α-amino butyric acid least rapidly. Accumulation of asparagine was most markedly increased by urea nutrition, whereas α-amino butyric acid was not significantly influenced by the nitrogen source. Arginine and glutamic acid N appeared to be somewhat decreased in the leaves under half light, whereas serine and asparagine were increased to some extent, though not consistently.

DISCUSSION AND CONCLUSIONS

The influence of nitrogen source and light on the growth of these plants must be kept in mind when the chemical differences are interpreted. The plants under half light and those with ammonium as the source of nitrogen produced less dry weight than those in full light, or those receiving NO_3 or urea N.

Accumulation of intermediary N compounds in the leaves was not directly correlated with growth. Thus, the "low light" plants did not have higher soluble N content (in concentration) than did the "high light" plants. Likewise the plants receiving NO_3 nitrogen were lower in soluble N than those receiving urea, which grew as well, and those receiving ammonia, which grew less well.

The fact that the young leaves contained less soluble N than older ones appears to result from more complete assimilation, or protein synthesis and/or translocation, than in older leaves, since the young leaves were also higher in total N.

The greater concentration of soluble N in leaves from the urea treatment than in leaves from the other treatments was correlated with greater total N. Thus, protein synthesis appeared not to keep up with synthesis of intermediary N compounds. There is no basis in this study for the determination of the factors limiting protein synthesis, but it is not inconceivable that light was a limiting factor in both the "full light" and "half light" treatments. This and/or other factors limiting growth may well have caused a piling up of intermediary N compounds in the older leaves at some distance from the apical growing region, in all of the treatments.

The reason for greater soluble N in the leaves from the urea reatment remains unanswered. Since growth was essentially the same s that of the plants in the NO_3 treatment the build-up seems to result from greater efficiency in absorption under conditions which imited protein synthesis and growth.

SUMMARY

The authors report on preliminary experiments to determine he contents of soluble nitrogen compounds in leaves of three different ages of cacao seedlings grown under two light intensities ith three different nitrogen sources (urea, ammonium and nitrate). he accumulation of intermediary nitrogen compounds in the leaves as not directly correlated with growth. Young leaves contained ess soluble nitrogen than older leaves, possibly due to more complete assimilation or protein synthesis or translocation in the younger leaves. Leaves of plants receiving urea contained more oluble nitrogen than those of plants receiving nitrate or ammonium nitrogen.

RESUMEN

Los autores informan sobre experimentos preliminares llevados cabo para determinar los contenidos de compuestos solubles de trógeno en las hojas de plántulas de cacao de tres diferentes ades crecidas bajo dos intensidades de luz y con diferentes ntes de nitrógeno (urea, amonio y nitrato). La acumulación compuestos nitrogenados intermediarios en las hojas no estuvo relacionada directamente con el crecimiento. Las hojas jóvenes tenían menos nitrógeno que las hojas adultas, posiblemente deo a una asimilación más completa ó síntesis de proteina o transación en las hojas más jóvenes. Las hojas de las plantas que cibían urea contenían más nitrógeno soluble que las que recibían rato ó amonio.

Table 2.

Total percentages of nitrogen, phosphorus, potassium, calcium and magnesium in the dry weight of cacao leaves 30, 60 and 90 days old, at the end of the experiment.

Treatment	Light	Age of leaves (days)	(% of dry weight in leaves) N	P	K	Ca	Mg
Minus nitrogen	Full	30	2.22	.38	1.45	.36	.32
	Full	60	1.90	.23	.95	.70	.45
	Full	90	1.63	.20	.68	1.68	.48
Ammonium	Full	30	2.91	.36	1.42	.14	.31
	Full	60	2.53	.29	1.12	.36	.32
	Full	90	2.54	.23	0.56	1.60	.59
	Half	30	2.88	.37	1.49	.10	.31
	Half	60	2.54	.34	1.30	.30	.41
	Half	90	2.49	.23	.66	1.50	.62
Nitrate	Full	30	3.17	.41	1.81	.40	.37
	Full	60	2.63	.27	.80	1.54	.49
	Full	90	2.40	.21	.64	.93	.46
	Half	30	3.18	.36	1.85	.45	.40
	Half	60	2.56	.30	1.04	1.30	.57
	Half	90	2.47	.18	.80	.87	.46
Urea	Full	30	3.50	.38	1.35	.35	.32
	Full	60	3.10	.28	.90	.75	.48
	Full	90	2.74	.24	.82	.69	.49
	Half	30	3.44	.37	1.66	.30	.35
	Half	60	3.00	.28	1.00	.67	.47
	Half	90	2.80	.22	.73	1.14	.52

le 3.

Intermediary nitrogenous constituents (expressed as N) determined in 30 day old leaves of cacao seedlings growing under greenhouse conditions. (Expressed as µg N per gram of dry weight).

no acids		Full light				Half light		
		NH_4	NO_3	Urea	-N	NH_4	NO_3	Urea
artic acid	2	3.9	6.5	15.4	0.5	1.8	2.1	19.9
tamic acid	3	46.6	103.7	115.1	39.9	54.7	56.6	69.9
ine	4	37.2	41.3	95.2	12.0	24.6	40.8	101.9
cine	5	16.1	12.1	15.8	7.4	14.0	11.2	14.7
aragine	6	86.9	113.8	320.1	----	79.5	100.7	434.6
eonine	7	8.0	9.6	12.6	8.2	8.5	8.0	14.2
ine	8	30.2	29.9	40.1	28.0	24.3	34.2	34.8
tamine	9	14.3	15.8	34.0	11.5	13.4	11.8	32.6
tidine	11	5.4	3.5	8.4	----	7.8	6.7	9.7
inine	13	122.0	99.0	87.0	----	83.0	83.0	109.0
line	15	18.0	9.8	16.2	----	12.1	9.4	21.2
ine	16	3.8	5.7	6.7	3.0	4.6	3.6	7.7
sines	18	9.6	9.3	9.7	7.9	8.0	5.3	12.1
osine	21	0.9	1.5	1.7	0.4	1.3	0.9	2.7
mino buty- acid	23	70.6	69.2	73.8	21.0	69.9	50.2	67.0
l determined		478.5	530.7	851.9		407.5	423.8	942.0
			1861.1				1773.3	

Table 4.

Intermediary nitrogenous constituents (expressed as N) determined in 60 day old leaves of cacao seedlings growing under greenhouse conditions (expressed as ug N per gram of dry weight).

Amino acids		Full light			Half light			
		NH_4	No_3	Urea	-N	NH_4	NO_3	Urea
Aspartic acid	2	8.9	15.7	30.8	1.0	7.9	13.3	34.7
Glutamic acid	3	72.3	115.6	117.5	70.0	91.3	93.7	71.8
Serine	4	92.6	105.2	161.2	15.3	49.5	95.2	165.2
Glycine	5	23.8	15.8	24.7	7.8	19.5	19.8	20.2
Asparagine	6	188.1	322.2	540.6		137.8	251.2	673.1
Threonine	7	13.6	24.7	20.1	7.6	18.8	14.5	15.2
Alanine	8	42.6	53.2	51.5	25.0	39.7	39.7	44.4
Glutamine	9	48.8	46.5	51.2	7.6	50.1	37.8	39.7
Histidine	11	13.3	7.8	15.1		17.6	11.3	7.6
Arginine	13	175.0	167.0	173.0		167.0	164.0	195.0
Proline	15	15.0	16.1	34.0	6.0	23.7	9.7	22.8
Valine	16	6.1	8.9	12.5	3.5	7.8	6.4	10.1
Leucines	18	9.6	13.0	17.8	7.1	11.5	9.8	14.4
Tyrosine	21	1.7	1.7	3.7	1.0	2.8	1.9	3.1
α-amino butyric acid	23	71.2	86.4	88.9	53.0	118.8	105.7	133.0
Total determined		779.6	998.9	1342.6		763.8	874.0	1450.3
			3121.1				3088.1	

able 5.

Intermediary nitrogenous constituents (expressed as N) determined in 90 day old leaves of cacao seedlings gr. wing under greenhouse conditions (expressed as ug N per gram of dry weight).

mino acids		Full light				Half light		
		NH_4	NO_3	Urea	-N	NH_4	NO_3	Urea
spartic acid	2	55.5	048.4	95.2	3.8	33.4	48.3	103.9
umatic acid	3	100.4	89.4	122.8	92.5	63.3	98.0	87.0
rine	4	85.8	83.9	126.6	14.0	63.2	79.9	147.9
ycine	5	16.6	13.0	16.5	7.6	16.1	10.2	14.3
paragine	6	363.0	348.5	597.8		302.1	256.4	548.5
reonine	7	23.7	14.5	20.8	8.8	28.3	15.5	16.9
anine	8	44.8	34.2	47.6	28.5	38.9	39.5	41.2
utamine	9	53.6	18.2	34.4	9.5	43.1	17.2	25.8
stidine	11	16.8	8.6	20.0		20.5	10.5	16.5
ginine	13	199.0	158.0	273.0		234.0	151.0	305.0
oline	15	24.1	14.0	33.7		32.2	15.8	25.2
line	16	9.9	6.5	10.7	4.2	8.9	7.9	9.5
ucines	18	10.8	8.7	12.5	8.3	13.0	9.1	14.1
rosine	21	2.3	1.2	2.9	1.7	2.7	1.5	3.1
-amino buty- ric acid	23	86.2	111.3	113.3	57.0	160.3	122.3	165.6
tal determined		1092.5	958.5	1525.4		1060.0	976.1	1524.8
			3476.4				3560.9	

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MINERAL FERTILISERS FOR COCOA AS DEDUCED FROM THE USE OF A TEST PLANT

Marcel V. Homes[M]

In previous papers we have described a method for determining nutrients requirements of a plant, the "Method of systematic ations" (1). That method gives a complete picture of fairly l value, of the whole nutrient medium suitable to ensure the ; growth or production. Applied in pure sand or water cul- experiments it gives what we call the "absolute total require- s" and, in that case, its meaning is essentially physiological method is indeed based on physiological principles).

Applied in soil culture (pot or field experiments) it gives cture of the requirements complementary to the nutrients effec- ly given off by the soil, i.e. the fertiliser suitable for best th or production. Such fertiliser, in order that it might con- ute in combination with the soil the best total nutrient medium, ssentially a complete fertiliser. Only exceptionally one or elements might be omitted. Still more exceptionally might it educed to a single element or fertiliser. But those cases may en, and we shall see an example in the present paper.

The purpose of this paper is to show that the differences be- n absolute total requirements (AR) and the local complementary irements (CR) can give the value of the local effective ferti- (LF), in one operation, for at least the major elements.

The local fertility is not a chemical characteristic of the , such as can be obtained by chemical analysis. It expresses equivalent, in nutrients, of what the soil is able to give off ng the period of experimentation (usually one growing season) r the action of the vegetation. The expression is given in nts (e.g. Kg) by surface unit (e.g. hectare) exactly as is for the fertiliser itself. Thus, it compares the soil (in local conditions) as a sterile substrate on which a first nt of fertiliser would have been spread.

We can obtain that picture of the local fertility by experi- ing with an annual. When we have the result and if we know on other hand the absolute requirements for another plant (e.g. a nnial on which experimenting is not so easy), the same line of oning can give the local complementary requirements for the same t.

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versity of Brussels

To sum up:

Test plant (annual)	AR - CR	=	LF
Culture plant (perennial)	AR - LF	=	CR

The complementary requirement for the plant the cultivation of which is considered is the fertiliser to apply for ensuring as good results as can be expected (practical optimum).

The examples given in this paper will clarify these ideas and illustrate them in the particular case of cocoa.

Examples of calculation of fertiliser for cocoa in three places in Belgian Congo, according to the method suggested.

a) The application of the method of systematic variations gives the following results as the absolute total requirements (major elements) for the test-plant (Zea Mays) and Cocoa (2). The figures are all in chemical equivalents and not in weight of conventional radicals such as P_2O_5, K_2O, etc. It is easy to pass finally from one expression to the other and we shall also give an example of that computation.

The absolute total requirements (AR) are independent of the amount or concentration. They are thus expressed in proportions of the various components in the total.

They are as follows:

Table 1. Absolute nutrient requirements (AR). Proportions in chemical equivalents in 100 chemi. equiv. total.

	NO_3	SO_4 : 2	PO_4 : 3	K	Ca : 2	Mg : 2
Zea Mays	22,6	17,0	17,0	14,3	14,8	14,3
Theobroma Cacao	19,4	15,2	17,8	11,9	16,0	19,7

b) Estimation of the total local fertility in terms of amount of fertiliser equivalent to that fertility:

The principle on which that computation is based results from the whole of our experimental work on

various species of plants. It is given here as a very simplified expression valid only in a range of concentrations (or amounts) of practical interest. The expression becomes more elaborate if it is intended to cover any value of the nutrient concentration or fertiliser amount.

The simplified expression is:

If yield = y

concentration or amount = x

$$y = k\, x^{0,5}$$

From the comparison of the control yield y_T and the average yield of the six "systematic treatments" y_M we can compute x in terms of E (the amount of fertiliser used for the comparison).

$$x = E \frac{y_T^2}{y_M^2 - y_T^2}$$

For instance, if 300 Kg /ha of fertiliser are used in the "Systematic treatments" and if 20% increase of yield are obtained ($y_M = 1,2\, y_T$) we have

$$x = 300 \times \frac{1}{1,44 - 1} = 690 \text{ Kg /ha}$$

The total local fertility is equivalent to a first amount of 690 Kg fertiliser /ha.

The same computation can be done using chemical equivalents.

Application to three places in Belgian Congo:

Table 2. Total local fertility in chemical equivalents per hectare.

Yangambi	35.100 (Central Congo)
Bambesa	25.000 (Uele)
Mvuazi	30.200 (Lower Congo)

These examples are developed for the sake of explaining and illustrating the method, without regard to the fact that the local climatic conditions might be unsuitable for cocoa growing. At least Yangambi and Mvuazi can be taken as actual examples of potential cultivation.

We then choose the fertiliser amount to be used. The composition of a complementary fertiliser is indeed depending on the amount used. We will make a choice of the amount of about 700 kg/ha or rather 17.500 chemical equivalents.

The total nutrients at the disposal of the plantation will thus be:

Table 3. Total nutrients (soil + fertiliser) in equivalents

Yangambi	35.100	+	17.500	=	52.600
Bambesa	25.000	+	17.500	=	42.500
Mvuazi	30.200	+	17.500	=	47.700

The next step is to determine the ideal or theoretical composition of those total amounts for the test plant (AR at the amount given in Table 3). Those figures are obtained by multiplying figures in Table 3 by the figures for Zea in Table 1.

Table 4. Amounts in chemical equivalents per ha.

Place	Total	NO_3	SO_4:2	PO_4:3	K	Ca:2	Mg:2
Yangambi	52.600	11.887	8.942	8.942	7.522	7.785	7.522
Bambesa	42.500	9.605	7.225	7.225	6.077	6.290	6.078
Mvuazi	47.700	10.780	8.109	8.109	6.821	7.060	6.821

On the other hand, direct experiments with Zea Mays in the field give the complementary requirements for that plant at the level of 17.500 chemical equivalents per ha, the chosen amount.

figures are given in table 5.

ble 5. Amounts in chemical equivalents per ha. Complementary requirements of Zea Mays (CR).

ace	Total	NO_3	SO_4:2	PO_4:3	K	Ca:2	Mg:2
gambi	17.500	4.780	2.385	2.385	2.305	3.340	2.305
besa	17.500	2.770	2.670	4.105	3.420	1.830	2.705
azi	17.500	4.780	2.580	2.190	1.190	3.580	3.180

local fertility (L.F.) for all components of the total al fertility as given in table 2 are computed by subction of the figures in table 5 from the figures in le 4 (AR - CR = LF).

le 6. Local fertility. Amounts in chemical equivalents per hectare.

	Total	NO_3	SO_4:2	PO_4:3	K	Ca:2	Mg:2
gambi	35.100	7.107	6.557	6.557	5.217	4.445	5.217
besa	25.000	6.835	4.555	3.120	2.657	4.460	3.373
azi	30.200	6.000	5.529	5.919	5.631	3.480	3.641

We then compute for Cocoa the ideal or theoretical position of the total amount of nutrients as given in le 3. It is obtained by multiplying the figures in le 3 by the figures in table 1 for Cocoa.

le 7. Absolute local requirements for Cocoa. Amounts in chemical equivalents.

	Total	NO_3	SO_4:2	PO_4:3	K	Ca:2	Mg:2
gambi	52.600	10.204	7.995	9.363	6.260	8.416	10.362
besa	42.500	8.245	6.460	7.565	5.058	6.800	8.372
azi	47.700	9.254	7.250	8.491	5.676	7.632	9.397

Then, the local complementary requirements (fertiliser) for cocoa is given by the differences between figures in table 7 and figures in table 6 (AR - LF = CR) (CR at the chosen amount of 17.500).

The results are given in table 8.

Table 8. Fertiliser for cocoa. Amounts in chemical equivalents per ha.

	Total	NO_3	SO_4:2	PO_4:3	K	Ca:2	Mg:2
Yangambi	17.500	3.097	1.438	2.806	1.043	3.971	5.145
Bambesa	17.500	1.410	1.905	4.445	2.400	2.340	5.000
Mvuazi	17.500	3.254	1.721	2.572	45	4.152	5.756

Let us observe that the Mvuazi soil gives us an example of a complete fertiliser which contains such a small portion of one element (K) that that element can be omitted in such a case, a "complete" fertiliser does not require potassium.

We only have then to transform those fertilisers expressed in chemical equivalents in terms of the usual technical fertilisers. For each of them we know its content in active elements. For instance Di-calcium phosphate obtainable in Belgium contains 38-39 % P205 and 35 % CaO or, per Kg of the technical product 16,23 chem. equiv. PO4 and 12,50 chem. equiv. Ca.

We give an example of three complete fertilisers computed for the three places as they can be prepared from technicals available in Belgium. Of course many other ways do exist to prepare fertiliser of same theoretical composition through the use of other technical products. The examples are given in table 9.

Table 9. Technical fertilisers for Cocoa (Kg per ha.)

Technical fertilisers	Local stations		
	Yangambi	Bambesa	Mvuazi
Di-calcium Phosphate 38-39 % P205	173	-	158
Superphosphate (triple) 47 % P205	-	226	-
Ammonium nitrate 20,5 % N + CO 3 Ca	211	96	221
Potassium Sulfate 48 % K20	102	235	-
Calcium Sulfate (Plaster, 95% pure)	20	-	42
Kieserite 27 % MgO	-	-	84
Magnesium Carbonate (without free oxyde) 95 % pure	227	221	202
Total amount per ha.	733	778	707

For practical purposes some allowances can be admitted in those compositions with the results that the fertilisers are rather less expensive or present some other advantages.

It is even possible, if one does not believe in the necessity of an adjusted percentage of S and Ca, i.e. if the ratio of N - P - K - Mg is considered sufficient in a fertiliser, to use the figures relative to those elements in table 8 to prepare such fertilisers, the preparation of which is then easier.

We have tested in a cocoa plantation in Mayumbe (Belgian Congo) a formula derived from those computations with very good success.

SUMMARY

The author describes the method developed by him for determining the fertiliser mixture suitable for best growth and production of a crop, known as the "Method of Systematic Variations". He shows how the method can be applied to cacao, using experimental results from three different sites in the Belgian Congo.

RESUMEN

El autor describe el método desarrollado por él para determinar la más adecuada mezcla de fertilizantes tanto para crecimiento como para producción de un cultivo. Se le conoce como "Método de variaciones sistemáticas" y se muestra como este método puede aplicarse a cacao haciéndo uso de resultados experimentales de tres diferentes localidades del Congo Belga.

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A TON OF CACAO PER ACRE?

D.B. Murray*

Increased production of cacao in the first half of the entieth century has been almost entirely a result of the planting of new areas to the crop. In many cacao growing countries hower, a limit has been reached to this and future developments must along the lines of greater production per acre. It is obvious, reover, that cacao from a high yielding acre is cheaper to produce an the same quantity produced from say 4 or 5 acres. How is it ssible to achieve high cacao yields with the corresponding reducon in production costs? Hardy (1939) has applied the Mitscherch equation for nitrogen utilisation to arrive at a theoretical ximum yield of 1500 lbs. of dry cacao per acre. He stressed, vever, that this was only an approximation and since yields well ove this figure are now being secured some of his assumptions were early incorrect. He considered 2000 lbs/acre a possibility and cussed some of the factors affecting high production. It is posed now to discuss research progress made towards achieving a h level of production per acre of cacao and the environmental tors concerned in the realisation of high yields.

old cacao estate

On the old cacao estate planted up in unselected seedling es the possibilities of any significant increases in yield are r, more especially if the trees are 40 years old or more. erience in Trinidad has shown that responses to manures and tilisers are in general uneconomic and attempts to rejuvenate trees by encouraging a single basal chupon to develop have not n worthwhile. Even budding high yielding selections on to these pons is not a practice that leads to much improvement. The suping of the vacant sites that always occur in an old field by the of high yielding rooted cuttings is a waste of valuable material. young plants do not compete successfully with the old trees und. The Cocoa Board of Trinidad & Tobago realises this and y permits planting where gaps of several trees occur. Even this ching up of an old field, however, is only a half measure and erience has shown that the best results can only be achieved by ting out the old trees and replanting with improved planting erial. Too few growers will face the fact that cacao trees do live for ever and that a policy of regularly replanting a pertage of their trees on a 35-40 years cycle can only make sense.

*Regional Research Centre, Imperial College of Tropical Agriculture.

Planting material

The history of the selection and proving together with th development of methods of propagation of the ICS clones is too we known to need repeating. At River Estate the best of these clon have given yields of 1200-1500 lbs. per acre over several years o a soil not particularly fertile or receiving much in the way of fertilisers. The use of the yields from small experimental plot multiplied up to give an acreage yield is subject to criticism and not unreasonably so but such yields have been secured from fields of several acres. The early yields of trials of introduced clones are showing that some of the Grenada and United Fruit Company sel tions are proving as good as the best ICS clones. Under more favourable conditions in Grenada such clones as GS 29 and 36 are giving yields of 4000 lbs/acre or more, albeit from small experimental plots.

As planting material, clonal cuttings have proved most successful - the annual production of 1¼ million by the Cocoa Boa in Trinidad is only half the actual demand - but there are disadv tages. The cuttings are not cheap to produce, though their cost repaid many times over in the additional cocoa they produce durin their life time, and their distribution to the planter presuppose a reasonably good transport system. These two disadvantages are overcome by the recent development of the hybrid seed resulting from crosses between Amazonian and ICS clones. At 6 years in the field the best of these had crossed the ton per acre mark at River Estate, Bartley (1957), and these yields are being maintained. Clearly too the best selections within these populations will be capable of yet higher yields and could be propagated as clones.

A final point on planting material. Murray and Cope (1959) have investigated stock scion relations in cacao to find out among other things whether combinations of two clones could give higher yields than either on its own roots i.e. were some clones more efficient as scions and others as stocks. It was found that clones, low yielding on their own roots, would give higher yields on more vigorous stocks. The highest yielding clones however gave yields as high on their own roots as on any other stock. Within the range tried, no stock scion combination performed better than the best clone in the combination on its own roots. Any practical development of grafted or budded plants would therefore appear to be very limited.

Sufficient has now been said however, to indicate that planting material capable of very high yields is now available to the cacao industry. The genetic potential is there; what of the environment?

vironmental requirements

No farmer would expect high egg production from the best of
ns if they were not housed and fed adequately, nor would hybrid
rn realise its potential high yield if unweeded and unfertilised.
o often the cocoa planter seems to think that the digging of a
all hole in the ground to take his future cacao tree is the major
eration overcome and that potentially high yielding material
ould then be able to carry on pretty well on its own. Only under
vironmental conditions approaching the optimum can the full genetic
ential of high yielding material be realised.

The general climatic requirements of cacao have been discussed
Murray (1955) and also some of the fundamental interactions with
environment by Fennah and Murray (1957). Ecologically, as an
er-story tree of the South American rain forest, the micro climate
highly buffered against variations in temperature, soil moisture
atmospheric humidity. This has been used as an argument for the
vision of similar conditions especially shade for the successful
wing of the crop. As the writer has stated before, however,
ao may grow and survive under such conditions but it does not
essarily follow that under such conditions the yields will be
h, in fact quite the reverse.

Before considering the atmospheric environment in more detail
ew general remarks on the soil are necessary more especially in
ation to the growth of the tree. Clearly interactions occur with
nfall and under high rainfall conditions physical structure is
y important. Deficiencies of nutrients may be made good by ferti-
ers but it is more difficult to ameliorate soil conditions where
er logging is prevalent and where poor aeration results in
uced root growth. Walmsley (1960) has recently shown the reduc-
n in growth of seedling roots at low oxygen levels. In a field
eriment, at the I.C.T.A. an attempt has been made to control soil
sture by covering the soil with tarred water proof paper to spill
t of the rain into surface drains during the wet season and this
combined with irrigation in the dry season, Murray (1957). So
results have been rather inconclusive and the differences in
ld from the controls have not been significant.

The effect of soil temperature can at present be only specu-
ion. Leaf flushing has been associated with atmospheric tempera-
e. Is root flushing controlled by the same mechanism or is it
pendent and related to soil temperature?

It has been known for sometime that cacao does not tolerate high soil pH being very susceptible to induced iron chlorosis. Less is known about low pH's but the tree may then suffer from toxic accumulations of manganese and possibly aluminium. In St. Lucia, Cope (1960) has found low yields to be associated with very high levels of manganese in the leaf. Optimal soil pH is probably between 5.0 and 6.5.

The wide field of fertiliser requirements will not be considered here. The existence of an interaction between nutrition and shade has been shown not only in Trinidad, Murray (1955) but at W.A.C.R.I. (Cunningham and Lamb, 1958) and must be borne in mind in any fertiliser studies. High yields are associated with little or no shade. A comparison with coffee is of interest. When this crop is grown without shade but with heavy applications of fertiliser yields are secured many times greater than those previously given under shade but with little or no fertiliser. Little attempt appears yet to have been made to try the same technique with cacao on a field scale.

A considerable amount of work has been done at the I.C.T.A. to try and develop a technique of leaf analysis as a guide to nutrient requirements but so far no really workable technique has been evolved.

As regards minor element nutrition, descriptions and illustrations of the results of deficiencies have been available for several years now but recently attention has been given to the special case of copper. Tollenaar (1959) first drew attention to the increased yields obtained by copper sprays as distinct from disease control and Nichols (1960) in sand culture studies is finding evidence that leaf copper may be low in the complete absence of any visual symptoms. The use of foliar sprays to correct minor element deficiencies is part of the broader field of foliar nutrition. In a new shade experiment laid down on a heavy clay soil at the Las Hermanas sub-station the treatments include a complete nutrient foliar spray.

A considerable amount of attention has been paid to soil organic matter and its decline from the high levels associated with forest land cleared for cacao to the low levels in old low yielding fields. Little is known however of the microbiology of cacao soils or of the significance of the mycorrhiza associated with cacao roots. What part do earthworms play in improving soil structure and aeration? Worm casts are plentiful in forest land; they are almost non-existent in old cocoa fields in Trinidad.

A recent experiment has been carried out on depth of oting of cacao. The same volume of soil was placed in a shallow x and in a deep box and root development of both cuttings and edlings observed after a year's growth. Little difference re- lted, good root penetration being obtained in the deep profile. lling the box however imparted an improved structure to the soil d conditions were not similar to an undisturbed profile. The fect of the competition of a shade tree on the growth of a cocoa ant in a small container has also been investigated but again th inconclusive results - there was little difference in growth the cacao in the presence or absence of Erythrina seedlings. ese experiments need to be repeated more critically.

Before leaving the soil aspect it is of interest to quote ne results from W.A.C.R.I. (1959). Growth of plants in sand and er culture and in soil was compared. After 4 months under proximately the same shade conditions it was found that leaf area l number of leaves of plants in sand culture were twice as great those in water culture and four times that of those in soil. ao in hydroponics? Hardly perhaps but significant of the neces- y for ameliorating soil conditions to secure optimum growth.

Turning now to the atmospheric environment, Hudson (1959) s that there are three main ways of increasing yield in relation the weather. The first is to breed varieties that are more erant of adverse weather conditions and will yield better crops er natural conditions than the varieties we grow at present. second is to modify the weather around the plant, either by tleties of cultural practice or by more expensive horticultural hniques. The third and most exciting approach though still in infancy and unproved as an aid to agriculture is the possibility altering the plants responses to the weather by using chemical mulants.

The first approach is of course well recognised more espe- lly in relation to annual crops where programmes of selection and eding for cold tolerance and drought resistance are well esta- shed. For the cacao breeder this would be an unevitable task gh of course a tree selected for say drought resistance could ays be propagated vegetatively. Cacao however, is seldom grown er conditions where average annual rainfall is likely to be tting, the more usual experience is the occasional dry season h is so severe as not only to reduce crop but even to kill the s. This may occur perhaps only once in 10 or 20 years but sub- mal moisture conditions usually occur for longer or shorter ods with every dry season.

This brings us to the second approach, the modification of the weather around the plant. This has been discussed by Murray (1955) but a few points may be expanded. The use of irrigation is obvious though an experiment under way at I.C.T.A. has so far failed to show any significant benefit in increased crop. The possibility must be considered that the low atmospheric humidity of the dry season leads to a rate of transpiration that the root cannot match even with adequate soil moisture. Further work on irrigation is planned. Another possibility lies in the use of an anti-transpirant, Murray (1955), which when sprayed on the leaves forms a transparent film that reduces water loss but has no phytotoxic effects.

Mention has already been made of the use of a waterproof soil cover to reduce water logging in periods of heavy rainfall. Speculating for the future, cloud seedling to produce rain may become practical and with this could be coupled the spilling of rain in the sea before it reaches the land during the wet season when too much rain might be disadvantageous.

Cacao as a crop is unusual in that it is so often grown under shade trees. The interaction of shade and mineral nutrition, Murray (1959), is now well established but there are additional factors that still need elucidation i.e. significance of shade tree competition, effect on soil moisture and atmospheric humidity etc. The fact is that although shade can and does act as a buffer to the plant against unfavourable factors in the environment, yields are lower under heavy shade.

This brings us to the point of how the plant reacts to the various factors of the environment. The old approach of trying to measure as many environmental factors as possible and then attempting to correlate one or other with growth and yield does not give the answers. Variations in one factor produce changes in others and not only are there long term annual variations in rainfall, temperature etc. but diurnal ones. The environment is in a constant flux. To study the individual components of the environment there has been developed the use of constant environment growth rooms. With control of temperature, light and humidity it is thus possible to study the response of the plant to any one of these. A unit of three such growth rooms is now being equipped at the I.C.T.A. Studies will be possible of the vegetative cycles of leaf flushing and the reproductive cycles of flowering and fruiting in response to one environmental factor at a time. Only with such fundamental knowledge will it be possible to indicate the optimal conditions for

gh yields. The problems of modifying the environmental factors ll then come to the fore.

It is at this stage that Hudson's third point must be consi-red. Major alterations in the environment may not be possible in e field but it may prove possible to alter the response of the ant to the environment. Since the plant responses must be through o-chemical mechanisms it may be possible to simulate an advantage-s environmental effect or cancel a deleterious effect by a chemical eatment. The known synthetic growth regulators, maleic hydrazide, bberellic acid etc. come to mind. These produce abnormal growth sponses in the plant, i.e. the habit of growth is modified irres-ctive of the environment. The effects of maleic hydrazide and bberellic acid have already been reported, Murray and Nichols 955), Nichols (1959).

Nichols (1960) has been working on this aspect of chemical ntrol in relation to Cherelle Wilt. Practically, if control of logenous auxins could be effected by chemical sprays a substantial duction in Cherelle Wilt and corresponding increase in crop should sult. Obviously however only through fundamental knowledge of the xin levels and their variation in the tissues can methods be de-sed for modifying hormone control.

Finally it is clearly useless to produce large numbers of ds if these or the parent tree are likely to succumb to diseases l pests. This subject will not be tackled now except to comment the remarkable success of the plant breeders in producing material sistant to Witches' Broom disease. The more universal problem of ack Pod may be more intractable in the absence of known resistant rains.

scussion

Research in recent years has shown that yields of cacao very bstantially higher than those secured by the average grower can be alised. Planting material of both rooted cuttings and seedlings s topped a ton of cacao to the acre under certain conditions. It the problem of the provision of the right conditions that usually vents the farmer from realising higher yields than he does.

It is obviously impossible to lay down in black and white a ndard procedure for growing cacao. The job of the research rker is to try to discover and elucidate the environmental factors it are significant in growing a crop and the way in which they eract. The final advice must be given in the field against such background of knowledge.

This translation into the field of the results of research is a matter for the extension officer and also involves problems of economics. The delay in applying new knowledge or rather in getting it applied may be very appreciable - it was some 15 years before the ICS selections reproduced vegetatively were planted to any extent in Trinidad.

Among the tropical tree crops cacao is particularly sensitive to its environment - the problems of crop forecasting are also related to this. A proper understanding of the physiology of tree is an essential prerequisite for providing conditions under which high yields per acre may be secured.

SUMMARY

The research progress that has been made in recent years towards increasing the yield per acre of cacao is discussed in particular relationship to environmental factors.

RESUMEN

Se discute el progreso de las investigaciones hechas en los últimos años para obtener aumentos de rendimientos por acre de cacao, especialmente sobre sus relaciones con los factores del medio ambiente.

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PAPERS ON BREEDING AND SELECTION

PLANT BREEDING AT THE WEST AFRICAN COCOA RESEARCH INSTITUTE

D. R. Glendinning*

Plant Breeding at WACRI was commenced by Posnette, who, having established that the cause of the decline and death of cocoa occurring in Ghana was a virus disease, sought for varieties resistant to it. First he studied the Ghana Amelonado; individuals surviving in virus outbreaks were tested to see if they had any inherent resistance, though without success. Next he studied such other types of cocoa as could be found in Ghana, Trinitario and Criollo types derived from introductions made around the turn of the century; some of these showed rather greater tolerance of virus than Amelonado, but no tolerance or resistance of value was found. Then he introduced a wide range of cocoa varieties and some other species from Trinidad. Among the cocoa varieties some from the Upper Amazon were more resistant to infection than Amelonado and were also considerably more tolerant of infection, but nothing approaching immunity was detected.

It should not be thought though that Posnette was uninterested in aspects other than disease resistance. He introduced many selections from various parts of Ghana to WACRI as budwood, budding in the field onto shoots from coppiced trees, and he propagated by cuttings from the resulting trees to establish clonal yield trials. He also introduced hand-pollinated seed from the original selected trees to establish progeny trials. Except in the case of trees surviving from Swollen Shoot outbreaks, his primary selection was based on yield, bean size, etc.

Before Posnette left WACRI in 1949 it was apparent that among those varieties introduced from Trinidad some, notably the Upper Amazons, were much more vigorous and higher yielding than Amelonado. The Amazons commenced yielding at about four years old while Amelonado was not expected to bear before it was 6 to 8 years old. When Rogers took over the work and was joined by Knight the emphasis in breeding definitely came to be on yield and quality. The Amazons were assessed, and, being found to be closely similar to Amelonado in flavour, their issue to farmers began. Eleven types representing the Nanay, Parinari, Iquitos and Scavina populations are now reaching the farmer. The total issue in Ghana up to the end of August 1959 was upwards of 125 million seed, sufficient with the farmers normal method of planting (3 seeds at a stake and about 800 stakes per acre) for some 50,000 acres, that is 80 square miles. Amazon is also being issued on a large scale in Nigeria, and some is reaching the farmer in Sierra Leone.

The presence of hybrid vigour in cocoa crosses was recognised (Knight and Rogers 1955), and before the acceptability of the Amazon varieties for quality was fully known crosses were made from them to

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* Plant Breeder, W.A.C.R.I., Ghana

elonado, and to other types known to be satisfactory, in the pe of ensuring the quality while obtaining hybrid vigour. The brids originally planted in 1952 and 1954 have since been plant- in a series of trials through Ghana and Nigeria, and are prov- g to be of very high vigour and yielding capacity. From the 1954 anting, yields of up to 100 lbs per acre were obtained in 1956, 00 lbs per acre in 1957, 1500 lbs per acre in 1958 and 2000 lbs r acre in 1959 (Potential yields, ignoring disease losses). Some the trials at offstation sites are growing with still greater gour, and though yield data are not yet summarised it appears at yields greater than 100 lbs per acre were obtained in 1959 m some 1957 planted trials. In one of these trials, at Fumso Ghana, stem diameter is increasing at the average rate of 2.4 per year with the best varieties in it increasing 2.7 cm per ar.

By 1956 the distribution of clones of the parents of these brids to the Divisions of Agriculture had commenced; these nes have been multiplied and the first seed gardens to pro- e the hybrids are being planted. This is being done in advance the approval of the varieties for issue. In view of their ge- al very high performance, which in all cases is satisfactory, roval for issue will hinge mainly on quality, though one hy- d is being held back because of high pod-disease susceptibi- y. Our requirements for quality are that the variety can be ed with Amelonado without impairing the uniformity of the t African crop. Not only is the uniformity of the crop a at commercial advantage, but the West African countries, k producers, must produce the type of cocoa required by the or manufacturers of chocolate, which is the Amelonado type.

The work described above was all done under the equivalent normal peasant-farm conditions, that is under shade of forest es and without fertilizer. Shade has been essential in the t to prevent the build-up of the population of Capsids (or ids), which could kill exposed cocoa. However, our entomolo- ts have achieved the control of capsids with suitable insec- ides and spraying machines. Not only does cocoa benefit di- tly from the destruction of the capsids, but in experimental ts at WACRI it has proved possible to remove shade entirely r large areas and still keep the cocoa in good condition.

The results from this are more than spectacular; yields n ordinary Amelonado have now surpassed any obtained in the eding programme at WACRI itself. 3,100 lbs dry cocoa per e were obtained from deshaded and fertilized mature Amelo- o at WACRI in 1958 (2350 lbs per acre from deshading alone hout fertilizer application). The yields obtainable from the hybrids when grown in this way are not yet known, but a

little over 3,000 lbs per acre was obtained from deshaded and fertilized Amazon cocoa in 1959 at Bunso, a Division of Agriculture station. Plantings of the new hybrids to test them out in these conditions have recently been made, and there is every reason to expect that they will once again leap ahead of Amelonado; but in the meantime the agronomic work has taken the lead over plant breeding. We hesitate though to recommend shade removal to the farmer, for it would be difficult for him to remove forest shade without causing extensive damage, and constant attention would be needed to keep down weeds if the canopy were incomplete, and to detect and deal with capsid outbreaks as they occur. The issue of a high yielding variety would not involve such problems.

Preparations are being made for a new cycle of breeding, to commence in about two year's time. The object will be, as before, to obtain hybrid varieties of rapid growth and high yield, but disease resistance is likely once again to be introduced into the programme as a major factor. Studies are being made of the reactions to virus of a wide range of Amazon types, and black pod susceptibility is being assessed. The reactions of the varieties to different soil and climatic conditions are also being investigated, and the vigour of various crosses as seedlings is being studied in the hope that it might give an indication of their potentials as mature plants.

SUMMARY

The first aims of the breeding program at WACRI were to seek varieties resistant to virus, but with little success. It was then observed that some Amazon types introduced from Trinidad were more vigorous and higher yielding than Amelonado, and were similar to it in flavour.

The breeding program then emphasised yield and quality, and hybrids between Amelonado and Amazon types and among the Amazons have given yields up to 100 lbs/acre at 2 years and 2000 lbs/acre at 5 years.

Capsid control, shade removal and fertiliser application have given yields of over 3000 lbs/acre. Higher yields can be expected from the hybrids with similar agronomic practices.

Disease resistance is likely to again become important in the next breeding cycle.

RESUMEN

Los primeros esfuerzos en WACRI se dirigieron a obtener varides resistentes al virus y causa del Swollen Shoot pero con poco to. Se introdujeron a Ghana varios tipos de cacao de Trinidad. observó que algunas introducciones del Amazonas fueron mucho vigorosas, tempranas y de más altos rendimientos que el cacao lonado. Su calidad se acerca a la del Amelonado.

El nuevo ciclo de mejoramiento se trató de buscar únicamente os rendimientos y calidad buena. Se observó gran vigor híbrido ltos rendimientos en las progenies de cruces de algunos clones zónicos entre sí y de éstos con Amelonado. Ensayos en varias alidades de WACRI indican rendimientos de hasta 100 lbs/acre a 2 años y 2000 lbs/acre a los 5 años de edad de algunas progeS.

El control de cápsidos, la remoción de sombra y la aplicación fertilizantes ha elevado las producciones del Amelonado a más 3000 lbs/acre. Es posible esperar más altos rendimientos con erial híbrido y las prácticas descritas.

En el próximo ciclo de mejoramiento se incluirá la resistena las enfermedades.

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SUMMARY OF DISCUSSION

Dr. L.M. Hutchins (ACRI)

Can we be given more details of spacing utilised in your trials, since these seem to vary from our practices.

Dr. D.R. Glendinning (WACRI)

As the farmer always uses a close spacing, and we cannot depend on being able to persuade him to change his system of cocoa cultivation, we are breeding varieties suited to close spacings. Most trials are therefore at 8 ft. spacing, though some are at 10 ft.

In an Amelonado spacing trial we have found that yields are relatively uniform at 5 ft. x 5 ft. spacing up to 7½ ft. x 7½ ft but at closer or wider spacings than these they are less. The trial is now about 14 years old, and there may be some tendency for the optimum spacing to increase with age, though I am not sure of the details. Amelonado, however, is a relatively tall and narrow tree, and there is little doubt that other types of cocoa may be better suited to wider spacings.

Height of tree is also a factor to be carefully watched. We are aiming at obtaining varieties that do not grow too tall, and one at present under test may have to be rejected for this reason. The West African farmer usually uses a harvesting pole of 14 ft. which with his own reach permits harvesting up to abou 22 ft., though harvesting at this height is not easy and the ide variety would not bear pods above perhaps 16 ft.

Mr. J. Braudeau (France)

I would like to know what is the quality of cocoa obtained on the trees.

Dr. D.R. Glendinning (WACRI)

The contribution to the crop from the 125 million Amazon seed that has been issued is probably small as yet, for this figure is for the period 1954 to 1959 so that most of the plantings are yet very young. Before this issue was commenced we assured ourselves that the quality was similar to West African, so that this issue should not upset the uniformity of the exported crop.

RENDIMIENTOS DE ESTACAS, DE PROGENIES DE SEMILLAS DE CLONES UF Y DE SEMILLAS NO SELECCIONADAS DE CACAO

J. Soria y L.A. Paredes *

En cacao, como en todo cultivo, se ha hecho esfuerzos para pro-cir material mejorado para la siembra de nuevas plantaciones. Has-la presente fecha, casi la totalidad del cacao del mundo proviene plantas de semillas no seleccionadas para altos rendimientos.

En 1931 en Trinidad se desarrolló el método de propagar árboles cacao vegetativamente por estacas (Pyke,1932-1934). Pound (1933) mismo Centro Experimental sentó los primeros criterios para selec-nar árboles superiores de cacao para rendimientos y para otros carac-es. Desgraciadamente, el uso de clones ha sido hasta la presente limitado debido al costo inicial de la propagación (instalaciones tosas y cuidados especiales) y las prácticas de cultivo posterio-, en contraste con el reducido costo de plantar y mantener una ntación de árboles de semillas.

Con posterioridad al desarrollo del método de producción de plan- superiores por medio de clones, se sugirió (Oechsli, 1955) el uso semillas de clones seleccionados como material mejorado y esta prác-a se ha generalizado en algunas localidades.

Jolly (1956) publicó los resultados de 13 años de un experimento ducido en Trinidad en el que se comparan los rendimientos de 3 clo- ICS propagados por estacas y de sus progenies de semillas de libre inización. Las estacas de clones fueron significativamente superio- a las progenies de semillas de clones.

Este artículo ofrece datos preliminares obtenidos de dos tipos de erimentos: uno plantado con clones, semillas de clones UF y plantas semilla de cacao no seleccionado (tipo "Matina") y otro, únicamente progenies de semillas de clones UF de libre polinización y cacao seleccionado.

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* Genetista y Administrador de la Finca "La Lola", respectivamente, Centro Interamericano de Cacao, Instituto Interamericano de Cien-cias Agrícolas, Turrialba, Costa Rica.

I . EXPERIMENTO DE COMPARACION DE CLONES, PROGENIES DE SEMILLAS DE CLONES UF Y CACAO NO SELECCIONADO

Materiales y Métodos

En 1955 se plantó en la finca "La Lola", situada en la costa Atlántica de Costa Rica, un experimento con 10 clones seleccionados por la United Fruit Company, 5 progenies de semillas de clones UF y plantas de semilla de cacao amelonado local "Matina". (Para identificación, ver cuadro No. 1). Se usó un diseño de latice cuadrado balanceado 4 x 4 con 5 repeticiones. Las parcelas tienen 6 plantas distanciadas 3 x 3 m. unas de otras. Cada repetición tiene una hilera de bordes de cacao "Matina", pero no hay bordes entre parcelas.

La sombra permanente es de Erythrina glauca y E. velutina plantadas a 12 x 12 m.

Los cuidados culturales en el experimento han sido podas de formación en los árboles de estacas, podas de mantención en todos los árboles, aspersiones mensuales con caldo Bordelés 4-4-50 para prevenir Phytophthora, y desyerbas.

Los rendimientos se registraron quincenalmente en número de mazorcas sanas y enfermas y en peso húmedo de las almendras por parcela.

Resultados

Los resultados en peso seco por hectárea (calculado multiplicando el peso húmedo por 0.35) y en número promedio de mazorcas por árbol del año 1959, se presentan en el cuadro No. 1.

Tanto en el análisis estadístico del peso seco como del número de mazorcas, el diseño de latice cuadrado balanceado no mostró eficiencia sobre el análisis por medio de un diseño de bloques al azar. Por esta razón, se usó el segundo.

En el análisis del peso seco se encontró diferencias altamente significativas ($P<.01$) en las comparaciones de clones contra progenies de clones y la de entre clones, no habiendo diferencias significativas entre progenies de semillas de clones.

En el análisis del número de mazorcas no hubo diferencias para la comparación de clones vs. progenies de semillas de clones, pero las diferencias fueron altamente significativas para entre clones y entre progenies de semillas de clones.

Una comparación más detallada de un cultivar vs. cualquier otro al nivel de P. 5% se presenta en el cuadro No.1 en donde cada promedio de parcela se compara con cualquier otro, mediante el método de prueba de intervalo múltiple de F. de Duncan (1955). Los cultivares comprendidos dentro de una misma línea vertical no tienen diferencias significativas entre sí, pero sí con los que no tengan ninguna otra línea en común.

II . EXPERIMENTOS CON PROGENIES DE SEMILLAS DE CLONES Y CACAO NO SELECCIONADO

Materiales y Métodos

En 1950 se plantó en la Estación Experimental La Hulera de Turrialba un ensayo con 6 progenies de los clones UF-676, 667, 613, 654, 650, 668 y de cacao local "Matina". El experimento está distribuído en un diseño de bloques al azar con 3 repeticiones de parcelas de 7 árboles a distancias de 3 x 3 m entre sí.

Este experimento fue parte de un proyecto de demostración de cultivo intercalado de bloques de cacao con hileras pareadas de Gliricidia que actúan como rompevientos y como sombra parcial.

En la finca "La Lola" se plantaron en 1955, 9 experimentos pequeños en diseños de bloques al azar. Cada experimento tiene 4 progenies de semillas de clones con 4 repeticiones de parcelas de 5 plantas puestas a una distancia de 4 x 4 m entre sí. La sombra es de Erythrina sp. en unos experimentos y de Inga sp. en otros. Los cuidados culturales dados a estos experimentos han sido: podas de formación y mantenimiento, desyerbas y aplicaciones mensuales de caldo Bordelés 4-4-50 en "La Lola" y de Cobre Sandoz en La Hulera.

Los datos obtenidos mensualmente en el experimento de La Hulera son el número de mazorcas por árbol y el peso-húmedo de las almendras de más o menos 30 mazorcas tomadas al azar del total de producción de la parcela. De este peso húmedo se calculó el peso seco (multiplicando por un factor 0.35) y se obtuvo el índice de mazorca para la muestra combinada de cada parcela y de allí para las progenies de cada clon. Con este índice se transformó los datos del número de mazorcas de cada año a su respectivo peso seco.

En los experimentos de "La Lola" se registró cada mes únicamente el número de mazorcas por árbol y por parcela durante el primer año de producción uniforme.

Resultados

En el cuadro No. 2 se presentan los datos de peso seco de cacao en Kg/Ha. y número promedio de mazorcas por árbol de 4 años sucesivos del experimento de La Hulera. Hubo fallas de datos de 1 a 2 meses por año en 1956, 1957 y 1958, pero estos fueron comunes a todos los tratamientos. Se hizo el análisis estadístico de ambos caracteres para los datos combinados de cultivares y de años. Se usó un diseño de parcelas divididas, considerando como tratamientos principales a las progenies de semillas de clones y como subtratamientos los años. Hubo diferencias significativas ($P < .05$) entre progenies de semillas de clones y diferencias altamente significativas ($P < .01$) para años.

El cacao "Matina" rindió significativamente menos que algunas progenies de semillas de clones, pero hubo diferencias significativas también entre algunas progenies de semillas de clones. En el cuadro No. 2 se muestra con líneas verticales las relaciones de significación entre las medias de las progenies de clones mediante la prueba de máximo intervalo de F de Duncan (1955). Las progenies de UF-676 y de UF-667 rindieron significativamente más que las de UF-613, 654, 650, 668 y "Matina". No hubo diferencias entre las demás progenies de clones y "Matina".

Los resultados del análisis del número de mazorcas son muy similares a los del peso seco; las comparaciones individuales por medio de la prueba de Duncan aparecen en el cuadro No. 2.

Los resultados de los rendimientos del primer año de los 9 experimentos de "La Lola" se presentan en el cuadro No. 3 expresados en número promedio de mazorcas por árbol y por parcela. Ninguna progenie de semillas de clones es común a todos los experimentos, pero la mayoría de ellas son comunes en dos o más experimentos (Ver cuadro No. 3).

Se hizo un análisis conjunto de los 9 experimentos. Se encontró diferencias altamente significativas entre experimentos y también entre progenies de semillas de clones. Se calculó la diferencia mínima significativa para comparaciones de las medias de rendimientos entre progenies presentes en uno, dos y tres experimentos en común. Estos valores se presentan al pie del cuadro No. 3.

Las diferencias entre experimentos se deben a ventajas en localización de suelos de algunos bloques.

Por medio de diferencia mínima significativa se tiene que las progenies de UF-613 rindieron en forma significativa más que las de UF-650, 676, "Matina", UF-221 y UF-672; UF-12 sobrepasó significativamente a UF-667 y "Matina" a UF-654 y UF-672.

DISCUSION

Los resultados de los experimentos de "La Lola" deben consi-
rarse como preliminares por provenir de un solo año de cosecha
de árboles jóvenes. Por otro lado, el tamaño de la población es
lativamente pequeño; sin embargo, merecen discutirse algunos pun-
s de importancia que en ellos se encuentran.

Los clones, que representan material genéticamente selecciona-
rinden en forma global significativamente más, al menos cuando
venes, que las progenies de semillas de clones; estos resultados
án de acuerdo con los del informe de Jolly (1956). Las diferen-
s altamente significativas entre clones indica que hay unos clo-
s superiores a otros. UF-221 es el mejor en 1959 y UF-667 y UF-613
los que le siguen como altos rendidores. De repetirse estos mis-
resultados en varios años se podrían recomendar éstos como bue-
para esta zona.

El hecho de que no se encontró diferencias altamente significa-
as entre progenies de semillas de clones indica que la selección
masa y de plantas individuales no es eficiente para obtener por
inización abierta progenies de altos rendimientos. Si se supone
el rendimiento es un carácter de herencia de tipo aditivo, los
dimientos de la población seleccionada no se alejarán mucho de la
ia del rendimiento de la población de donde se obtuvieron los clo-
.

Es posible alcanzar pequeños progresos como se evidencia en al-
os de los rendimientos aquí presentados, pero éstos no serán acu-
lativos al prevalecer libre polinización con clones o cacao del
mo origen y tipo.

Las progenies de semillas de clones rinden consistentemente más
el cacao "Matina" no seleccionado; pero estas diferencias en ren-
iento no son significativas. Esto se debe en gran parte a la alta
niabilidad de este carácter dentro de cada población de semillas de
nes.

Algunos de los altos rendimientos de ciertas progenies pueden
erse a que algunos clones de la UF provienen o de cacao Trinitario
roducido o de cacao Nacional del Ecuador. Al cruzarse estos clones
cacao amelonado local "Matina", es posible que se obtenga vigor
rido. Este parece ser el caso de las progenies de UF-676 y 667 en
Julera, cuyas plantas muestran la presencia de genes del poliniza-
"Matina" en la forma amelonada y color blanquesino típicos de es-
variedad.

Los resultados preliminares de los análisis del peso seco y del número de mazorcas en el Experimento I confirman que no es posible usar como regla general el dato del número de mazorcas producidas por árbol como indicación de su rendimiento en peso seco, ya que este último depende de los caracteres de índice de mazorca y de semilla. Estos a su vez están íntimamente relacionados con el tamaño de mazorca y de semilla. En clones es más factible transformar rendimientos estimados en número de mazorcas a peso seco, si se conoce el índice de mazorca en cada región. Sin embargo, datos no publicados de este Instituto, indican que hay mucha variabilidad de este carácter durante el año en un mismo clon. Esto no es posible en progenies de semillas de clones y en poblaciones híbridas de padres heterozigotes para rendimientos y sus caracteres relacionados. En la práctica general, no es posible registrar pesos individuales en cada árbol. Sin embargo, sería conveniente obtener un índice aproximado de transformación del número de mazorcas a peso seco para cada tipo de progenie. Para esta finalidad sería de mucho interés conocer la heredabilidad del carácter índice de mazorca y sus componentes. Aparentemente esta heredabilidad es baja, como se puede deducir de la gran variabilidad en rendimientos en peso seco de las progenies de semillas del mismo clon en experimentos diferentes. Aunque los datos de rendimientos de La Hulera y los de "La Lola" no son estrictamente comparables, en términos generales demuestran la gran variabilidad de progenie a progenie y de árbol a árbol y la imposibilidad de predecir rendimientos con progenies de semillas de polinización abierta. En La Hulera las progenies de los clones UF-676 y 667 fueron las de mayor producción en mazorcas y peso seco, mientras que en "La Lola" ocuparon los sitios más bajos en producción.

Tomando sólamente los resultados del experimento en La Hulera, el paralelismo de resultados aproximado en los análisis de pesos secos y número de mazorcas por parcela indicaría que se podría usar el último dato como representativo del rendimiento en peso seco, o que el método usado para estimar peso seco es inadecuado. Pero los resultados del Experimento I de "La Lola" muestran que no hubo relación entre la estimación del número de mazorcas y el peso seco de progenies de semillas de clones en las que se registraron los pesos húmedos de cada parcela.

En referencia al método usado de tomar el peso húmedo mensual de las almendras de alrededor de 30 mazorcas tomadas al azar de cada progenie y de éste estimar el peso seco y el índice de mazorca, debiera ser investigado en más detalle. Se debiera obtener en cada árbol por un periodo de tiempo el peso húmedo de las semillas, tomar el peso húmedo de las semillas en muestras de mazorcas al azar de cada progenie y estudiar estas correlaciones. A la presente se hace muy necesario obtener un método de estimar con aproximación los rendimientos en

se al número de mazorcas cosechadas para los trabajos de evaluación de las progenies de híbridos interclonales. Esto sería relativamente facil al tratarse de poblaciones uniformes, pero resulta y complejo con poblaciones resultantes de cruzamientos de padres terozigotes y de progenies de semillas de clones a libre polinización.

RESUMEN

Se presentan resultados en kilógramos de peso seco por hectá- por año y número de mazorcas por árbol de dos tipos de experitos: uno con estacas de clones UF, progenies de semillas de clo- y cacao no seleccionado del tipo amelonado local "Matina" y o con progenies de semillas de clones UF y cacao "Matina".

Los resultados preliminares indican que los rendimientos en peseco de clones propagados por estacas son significativamente mas os que los de progenies de semillas de clones a libre polinización. diferencias altamente significativas entre clones y ocasionalmenentre progenies de semillas de clones; pero en general las proges de semillas de clones, aunque consistentemente rindieron mas que cacao local "Matina" no seleccionado, no son significativas.

Los resultados en número de mazorcas son muy variables y no ecen una indicación real del rendimiento en peso seco. Se discu- las relaciones entre peso seco y número de mazorcas.

Las progenies de semillas de libre polinización de clones de un n son muy variables dentro de un mismo experimento y de un experito a otro. No es posible predecir ganancias apreciables en rendiitos con este tipo de material.

SUMMARY

Yield results in weight of wet cacao and numbers of pods are ented for two field experiments comparing cuttings of UF clones, -pollinated seed from UF clones, and unselected cacao of the lo- "Matina" type of Costa Rica.

The early results show that the cuttings yielded significantly than the open-pollinated seedlings of the clones in weight of cacao. The open-pollinated seed from clones yielded consistently than the unselected "Matina" cacao, but the differences were not eneral statistically significant.

Yield results expressed as numbers of pods were highly variable and did not give a reliable estimate of yield. The relationships between numbers of pods and dry weight are discussed.

The yields of open-pollinated seeds from clones are very variable and one cannot predict appreciable gains in yield using this type of planting material.

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uadro No. 1 - Peso seco (Kgs/Ha.) y número de mazorcas (promedio por árbol) de 10 clones, 5 progenies de clones UF y cacao "Matina", correspondiente a 1959. Finca "La Lola", Costa Rica.

Peso Seco			Número de Mazorcas		
ıltivar	Kilos/ hectárea	Promedio/ parcela	Cultivar	Promedio/ árbol	Promedio/ parcela
UF-221	1.757.63	9.49	UF-221	25.0	150.0
UF-667	1.329.74	7.18	Pl.UF-613	19.0	113.8
UF-613	1.249.63	6.72	UF-613	18.5	110.8
.UF-650	1.066.20	5.76	Pl.UF-667	17.5	105.2
.UF-613	992.96	5.36	UF-667	17.4	104.2
UF-677	966.39	5.22	Pl.UF-650	17.2	103.2
UF-12	960.29	5.19	UF-668	14.4	86.6
UF-654	945.39	5.10	UF-677	13.5	80.8
.UF-667	918.81	4.96	Pl.UF-221	12.0	71.8
UF-650	899.63	4.86	UF- 12	11.6	69.6
UF-668	815.24	4.41	UF-650	11.2	67.2
UF-168	750.81	4.05	UF-168	11.0	66.0
UF-676	726.44	3.94	Pl- Matina	10.5	62.8
.UF-221	690.10	3.73	UF-654	8.8	52.6
.UF-676	571.10	3.08	UF-676	8.7	52.2
.Matina	540.16	2.92	Pl.UF-676	7.8	47.0
edia de clones/parcela	= 5.61			84	
edia de semillas de clones/parcela	= 4.30			83.9	
1	= 0.88			7.58	

.. = Plantas de semillas

Cuadro No. 2 a) Peso seco (Kgs/Ha); b) número de mazorcas (promedio por arbol) de cultivar/año de 7 progenies de semillas de clones UF, correspondientes a 4 años. La Hulera, Costa Rica.

Progenies de Semillas		1956	1957	1958	1959	Promedio Kg/parcela	Promedio mazorca/parcela
UF-676	(a)	1.785.3	2.078.0	1.806.8	2.195.6	27.3	
	(b)	43.9	51.1	44.5	54.0		338.8
UF-667	(a)	1.314.9	1.775.7	935.8	2.022.8	21.0	
	(b)	25.3	34.2	18	39.0		203.8
UF-613	(a)	875.8	712.7	1.036.6	1.444.5	14.1	
	(b)	19.1	15.6	22.7	31.6		155.7
UF-654	(a)	818.2	914.2	758.2	1.312.5	13.4	
	(b)	23.9	26.6	23.3	38.3		196.4
UF-650	(a)	784.6	529.1	652.7	1.317.3	13.2	
	(b)	15.8	21.0	13.1	26.4		133.4
UF-668	(a)	791.8	950.2	499.1	983.8	11.2	
	(b)	21.4	25.6	13.5	26.6		152.5
Matina	(a)	345.5	739.1	576.7	1.180.6	8.8	
	(b)	7.8	16.7	5.9	26.8		100.2
S_m Peso Seco			=			2.26	
S_m Número de Mazorcas			=				27.3

uadro No. 3 - Rendimientos promedio (mazorcas por árbol) de 10 progenies de semillas de clones UF. "La Lola", Costa Rica

rogenies emillas Clones	Experimentos 1	2	3	4	5	6	7	8	9	Promedio/ parcela
-613	11.8		8.0	7.6	7.4					43.3
-12							3.8	2.3	13.0	31.9
tina	9.5	2.1	6.1							29.3
-677							2.2	1.7	19.4	29.0
-221		1.2	2.6	1.1	0.2					25.4
-650	4.8	1.7		1.2	1.0	2.2	4.7	0.9	14.2	19.0
-676	4.7				3.6	3.1				18.9
-654		3.0				3.4				15.9
-672			4.2	2.2		2.3				14.4
-667							1.0	1.5		4.1

M.S. (P=.05) para promedio por parcela progenies comunes en Experimento 1 ..... 7.7

M.S. (P=.05) para promedio por parcela progenies comunes en Experimento 2 ..... 12.3

M.S. (P=.05) para promedio por parcela progenies comunes en Experimento 3 ..... 15.1

CLONAL AND FERTILISER EXPERIMENTS IN TRINIDAD AND TOBAGO

A.L. Jolly* and L.L. de Verteuil**

This series of experiments is a cooperative venture between the Cocoa Board of Trinidad and Tobago and the Regional Research Centre at the Imperial College of Tropical Agriculture. Officers of these bodies have worked in close collaboration, particularly at the planning and planting stage of these experiments. The main individual responsibilities that have subsequently been assumed are as follows: the Cocoa Board for laying out the experiments producing the required planting material, the application of fertilisers and general direction of the cultivation of the experimental areas; and the Regional Research Centre for the recording and analysis of yields.

One important feature of these experiments is that, with the exception of two sites (River Estate and Louis D'Or), all were conducted on privately owned and commercially operated estate land. Such an arrangement was obviously necessary in a series of experiments that required a wide range of soil types but it also led to conditions that are by no means usual on experimental areas. The most important condition was that although the standard of cultivation was generally satisfactory it varied considerably from one estate to another. Such variability may perhaps be considered undesirable as increasing between-experiment errors. On the other hand there is a very practical advantage in conducting experiments under actual conditions of commercial production rather than under ideal ones that are usually aimed at on a research station.

The siting of the experiments on commercial estates and the cost involved in recording about 35 scattered acres by other methods led to the adoption of a rather unorthodox method of yield recording. Previous experience of the first author has shown the practical difficulty, the high cost and sometimes the unreliability of determining cocoa yields on commercial estates directly by weighing wet beans. The difficulty arises from the fact that an estate is harvested in sweeps over the whole cultivation at irregular intervals according to the crop. It is often difficult for the planter

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* Lecturer in Economics, Imperial College of Tropical Agriculture.

** Technical Officer (Research), Ministry of Agriculture. Chairman of Cocoa Board.

notify the research centre sufficiently long and sufficiently actly in advance of the day on which a small experimental area will xt be harvested. It is, therefore, correspondingly difficult for e research centre to plan the supervision and recording of the rvest at all efficiently, and additional field staff has to be ailable to cope with the height of the crop and with unusually ort notifications by planters. Even so, there is a real risk that reaping may be completed without the recorder being present and the ole season's recorded production is correspondingly inaccurate.

This practical difficulty of obtaining wet bean weights for periments on estates can be overcome by the research centre suming the responsibility for harvesting. However, to be certain at estate labourers do not inadvertently harvest some of the experintal trees, it is usually necessary for the research centre to undertke all cultural operations which obviously is expensive and results plots managed to experimental and not to commercial standards.

eld Records

The procedure therefore adopted for yield recording in these periments was that developed and described by Shephard.[17] Briefly, consists of counting all pods that are expected to mature in the suing three months and requires a count usually three times a year. smallest pod counted is marked with white paint so that it can recognised on the next visit as being too large to count and none re mature is recorded at that visit. The average weight of the ntents of pods has been estimated from two experiments (River tate and Poole Syndicate) on which weighing as well as pod counting s practised; the product of these weights times the number of pods ves the estimated yield.

The inaccuracies of this method of estimating yield arise iefly from the mortality of young pods which become diseased subquent to counting. All mature pods that will obviously yield no oa are excluded from the count. In areas where pod damage inuding Witches' Broom disease is serious this system would require ch more frequent counting than three times a year in order to be asonably accurate. More frequent counting did not seem justified these experiments because these pod casualties were either unimrtant or sporadic in their occurrence. The field counter was quired to make numerous observations on the condition of each ividual tree including the incidence and causes of pod losses. ese observations could not, however, be made on a sufficiently ecise statistical basis to be used as adjustments for the estited true yield and were in fact intended more to indicate general nditions that pertained.

Some idea of the overall accuracy of this method is given on River Estate, the I.C.T.A. cocoa experiment station, on which bean weighings were made. The estimated yields per acre for each clone for the 1st Line experiments are given in Table 1. Although there appears to be a general tendency for over-estimation by the counting method as would be expected, it appears to be serious only for a few clones. The incidence of Witches' Broom and Black Pod at River Estate from general observation appears to be about average for all experiments. In one of the worst experimental areas as regards Witches' Broom and Black Pod (i.e. Poole Syndicate, 17% pods lost from both causes in 1959) the pod counting over-estimated the yield by as much as 26 per cent. Obviously if all experiments had this degree of infection more frequent counting would have been necessary to obtain the actual as well as the potential yield.

It may be pointed out that although it would be theoretically desirable to have complete agreement by the two methods of yield estimation there would still be a considerable margin of experimental error in assessing the productivity of individual clones under the conditions of the experiments. The Standard Error between clones in individual experiments was about 30 per cent. of the average yield. These inaccuracies in recording are of course far less important in the fertiliser than clonal experiments because fertiliser treatments are not likely to be correlated with the incidence of pod losses. A general bias to over-estimate yields would not be expected to distort fertiliser responses seriously.

The possibility by the use of the pod counting method of reducing the yield recording to a regular routine which is unaffected by season, by the work programme on individual estates, etc. allows for great economy in cost of this work. The yield recording of these experiments has been performed by one field assistant who, with the help of usually two local labourers, is able to record some 22,000 trees. The fact that he counts trees individually greatly simplifies the field work and the subsequent statistical analysis particularly where fields are irregular and rather involved statistical designs are employed. For the purpose of counting it is unnecessary to identify the plot and treatment provided the individual tree is clearly labelled with a serial number. These tree counts have been efficiently analysed in the office into plot, treatment, etc. totals by the use of peripheral perforated cards, basically one card representing one tree site.

TABLE 1

Comparison of Yield Estimates, 1st Line River Estate, 1957/8 and 1958/9 (dry cocoa per acre per annum, lbs.)

Clone	By Pod Counting	By Weight Wet Cocoa	Difference as % of Wet Cocoa Estimate
ICS 1	847	847	0
6	689	739	- 7
8	901	771	+17
32	771	838	- 8
39	1268	1136	+12
40	1623	1369	+18
43	1068	957	+12
46	1154	1218	- 5
47	1054	993	+ 6
48	1364	1100	+24
60	1132	1006	+12
61	1066	758	+41
IMC 67	1489	1563	- 5
ICS 75	611	799	-23
84	837	757	+11
89	1046	818	+28
95	870	740	+17
98	516	469	+10
100	851	660	+29
Mean	988	907	+ 9

Type and Layout of Experiments

The objectives of these experiments were threefold: (i) To test under estate conditions the performance of clones already well known in 1950 chiefly to give the Cocoa Board more reliable guidance in their production and plant distribution policy; these are the 1st Line Clonal trials. (ii) To examine a larger number of more recent clonal introductions and to ensure that the potentialities of none of the clonal material then available had been overlooked; these are the 2nd Line Clonal trials. (iii) To examine on a more comprehensive basis than had previously been attempted the basic yield response of cocoa to the three main fertiliser elements. The need for this latter rather elementary experimentation was that previous fertiliser experiments had given inconclusive or conflicting results and it was considered necessary therefore to lay down the most basic investigation but carried out on a sufficiently comprehensive scale to give clear cut answers.

The experimental design of both clonal experiments was the same, that is a 21 treatment balanced incomplete block design consisting of 5-plot blocks and 5 replications.(2) In both experiments guard rows, or strictly speaking pollinator rows, were planted between every line of plots. SCA 6 and SCA 12 were most commonly used for this purpose.

In the twelve 1st Line experiments there were, with one exception, 6 trees to the plot, or 630 in the experiment. With the pollinator rows these experiments occupied about 1¾ acres at 9' by 9' spacing. The 21 clonal treatments were intended to be identical in all these experiments but it proved impossible to obtain sufficient planting material for two of them (ICS 79 and ICS 91) and these were planted with substitutes. All except IMC 67 were Imperial College selections chiefly for the reason that in order to qualify for inclusion in this experiment clones had to be backed by some previous yield records. Such records in 1950 were limited almost entirely to the Imperial College clones.

The eleven 2nd Line Clonal trials had with three exceptions (6 trees) 4-tree plots and thus occupied about 1 acre each. The clones were varied somewhat from one experiment to another in order to accommodate all new promising clones and in proportion to the amount of planting material available. Six clones were common to all experiments and another thirteen occurred quite commonly. In all, 35 clones were tested including 16 second rate Imperial College selections. ICS 95 (also in the 1st Line) was included in every

periment as a control. The intention of these experiments was fact not to make fine comparisons between individual clones, tes, etc., but to discover any outstanding new clones that might eviously have been overlooked.

The design of the fertiliser experiments was a simple 2^3 ndomised block. The treatments consisted of the presence and sence of the three fertilisers, sulphate of ammonia, super- osphate and muriate of potash, at a rate of ½ lb. per tree or out 250 lbs. per acre applied once a year at the beginning of e wet season. The fertiliser plots were split to accommodate o clones, ICS 1 and 95, and the 2nd order fertiliser interaction xPxK) was confounded with blocks usually 8 in number. The andard experiment had 16 trees per plot.

No guard rows were used for these fertiliser experiments i it would appear that they were unnecessary. The experiment obably in most need of guard rows because of the general slope the ground, the high rainfall and the general impervious nature the soil was Poole Syndicate. This experiment was re-analysed owing a guard row round each plot to see whether non-significant sponses from the whole experiment were due to the fertiliser atments washing from one to adjoining plots. The conclusions this re-analysis were identical with the original and the sponses to the two most soluble fertilisers, N and K, were vir- lly identical with those obtained originally.

The clonal cuttings under trial are those of interest and ilable in 1950, hence the preponderance of Imperial College ections. These were made by Pound in 1932/3 from the cocoa ulation existing in Trinidad and Tobago. The selections erally have a larger pod and larger beans and appear to contain arger proportion of Criollo type pods than the typical Trinidad dling population. Many of these clones bearing Criollo type s display full Trinitario vigour and, it will be seen, are among heaviest bearers. The Imperial College selections can be divi- into Trinitario and Criollo pod type as follows:

nitario type:	ICS 1, 6, 8, 9, 16, 22, 32, 35, 37, 44, 49, 53, 70, 73, 75, 84, 85, 89, 91, 95, 98.
ollo type:	ICS 38, 39, 40, 43, 45, 46, 47, 48, 60, 61, 87, 90, 100.

ne E 660 is also a local Trinidad selection obtained in 1950 m a recent planting mainly of open pollinated seeds of some erial College selected parent trees.

Other Trinitario clones have been selected overseas and imported as cutting or budwood from Grenada (G.S.), Dominica (D.S. and Surinam (S.P.).

PA and IMC clones, the latter apparently seedling progeny of P 18, were imported as seeds by Pound from Peru in 1937.(3) Th two P clones were imported as vegetative material in 1943 from trees observed in the Iquitos district(4) of Peru as Witches' Bro free in 1937 and had remained so at the time of selection. All these clones are of the Amazon forastero type.

Experimental Sites

Twenty-eight possible sites were examined and reported on by the Soil Scientists of I.C.T.A. and the (then) Trinidad Depart ment of Agriculture. Of these, fourteen were chosen as representing a good range of types but two of these had subsequently t be discarded as presenting unsatisfactory field conditions. Area were usually prepared in the wet season of 1951 and planted in clones in 1952. An additional experimental site (San Jose) was planted one year after the others. The resulting thirteen sites were utilised as indicated in Table 2.

The elaborate chemical and physical analyses from soil p on the selected sites gave very variable indices which make it difficult to generalise about the soil characteristics even withi the broad groups, Trinidad Clays, Other Trinidad Soils and Tobago Soils. However, Tobago Soils are generally lighter in texture than Trinidad; the exceptions are at Studley Park and Campbellto where the non-sand fractions (67%) are as high as, for instance, Santa Severa on Trinidad Clays. However, both these Tobago site are on steeply sloping ground which might well diminish the disadvantages of their rather impervious nature. Arethuse, El Toco and River Estate (i.e. Other Trinidad Soils) have a much lighter texture than the Clays which contain non-sand fractions of 76 per cent. to 91 per cent. The generally heavy nature of the Trinida Clays is also shown by the index of texture, Poole Syndicate and San Jose having the highest index at 3" and also (along with El Rosario and San Francisco) the highest at 18". Some Tobago soils (King's Bay and Louis D'Or) show a very low index of texture and at 18" consist virtually of gravel and sand. One set of these physical analyses does not seem to fit the actual conditions of the experimental area and may be due to poor siting of the soil pit. Santa Severa is situated on typical bad Brasso Clay whereas many features of the analysis do not seem to correspond with such a condition.

TABLE 2

Utilisation of Experimental Sites

Site	1st Line Clonal Experiment*	2nd Line Clonal Experiment	Fertiliser Experiment+	
			Repli-cations	Trees per sub-plot
Trinidad Clays				
El Rosario	6 tree plots	4 tree plots	8	8
Poole Syndicate	6	4	8	8
San Francisco	6	4	8	8
San Jose[x]	6	6	8	8
Santa Severa	6	4	8	8
Trinidad Other Soils				
Arethuse	4	4	-	
El Toco	6	4	-	
River Estate	6	6	8	8
Tobago Soils				
Campbellton	6	4	8	6
King's Bay	6	-	-	
Louis d'Or	6	6	-	
Richmond	-	-	8	8
Studley Park	6	4	6	6
Total Number of Experiments	12	11	9	

* 21 treatment balanced incomplete blocks of 5 plots, 5 replications.

+ 2^3 randomised block split for 2 clones.

x Planted 11' x 11' (all others 9' x 9') in 1953, i.e. 1 year after other experiments.

The Organic Matter content of these soils at 3" varies from 2.5 per cent. on Arethuse to 6.6 per cent. on Studley Park. There seems no correlation of these percentages with the type of soil and the variation is probably partly due to the type of vegetation which cover the site immediately previous to sampling. For example, Arethuse had been used for wartime food gardens up to three years of the time of sampling which may well account for the low Organic Matter; Studley Park, on the other hand, was in overgrown semi-abandoned cocoa.

The C/N ratio suggested by Hardy(5)as a good indication of the productivity of cocoa soils appears to fit quite well considering all circumstances with the productivity of these experiments. The Tobago Soils have the highest ratio (9.2 and over/1), Arethuse and Poole Syndicate, 8.1 and 8.5, and Other Trinidad Clays, except San Jose, under 8.

The Trinidad Clays are the most acid soils (pH below 5.7) with the exception of Poole Syndicate and San Jose where widespread calcareous deposits raise the pH to the highest on any site (7.4). Of the Other Soils, Arethuse is very acid with the lowest pH at 4.5. Available phosphate is generally deficient in Trinidad Clays, Arethuse and Campbellton; it is adequate on other Tobago sites and El Toco, and abundant on San Jose. Available potash is deficient on Tobago sites and San Francisco, abundant on Poole Syndicate and San Jose (see Appendix 1).

The effects of these soil characteristics on the productivity of cocoa are greatly modified by other conditions. The average annual rainfall varied from about 65" a year at River Estate to 120" at San Francisco and at some, for instance, El Toco, was more unpredictable than others. Sites which might be expected to be affected by rainfall were as follows: Risk of Excess Rainfall (considering soil and topography): El Rosario, San Francisco, Poole Syndicate. Risk of Drought effect: San Jose, El Toco, Campbellton.

Years for which the yield analyses are given (1957/8 and 1958/9) have been generally dry and the total precipitation is about 15 per cent. below normal. Some of the sites are more exposed than others. Those likely to be affected by exposure are: Arethuse, El Toco, Campbellton and King's Bay. Santa Severa and El Rosario have suffered landslips.

The initial planting of the experiments met with different degrees of success which has resulted in further variability between

experiments. The reasons were numerous and emphasise the known fact that the field management of the cocoa crop is l an art and, particularly at the planting stage, needs con- t expert supervision. The success of planting was influenced he general standards of management, the thoroughness of blishing temporary ground shade, the soil situation and topo- hy of the site and the vigour of the cocoa cuttings supplied. establishment difficulties on the less favoured plots were rtunately exaggerated by the decision to plant the experi- s at 9' x 9' without permanent shade. Two years after ring the condition of the less satisfactory experiments was oor that it was decided to plant permanent shade throughout of them although it was realised that the compromise of close ting with shade is not ideal. The after-cultivation of some he experiments has not been entirely satisfactory particularly egards the pruning of the cocoa trees and the regulation of density of permanent shade.

It is clear that although the original intention in cting these sites was to compare different soil types, this or is confounded with the large number of others discussed e. Nevertheless, the 13 sites do represent a comprehensive e of conditions under which cocoa is commercially grown in idad and Tobago. In Table 3 an attempt is made to assess the rent suitability of the sites for cocoa production. The l ranking is arrived at by modifying the order of yield ob- ed, 1957/8 and 1958/9, by the number of original trees sur- ng in the field and a rough estimation of the skill of after- ivation. For instance, Poole Syndicate which ranks as 7th ield has been demoted to 9th=because it enjoyed particular gement advantages; due to good plants and good management, er cent. of the original plantings survived and the general r-cultivation management was rated as first class. This e, even if rather subjectively constructed, indicates clearly superiority of Tobago sites and the inferiority of Trinidad s, except San Jose.

Development of the Experiments

Table 4 gives the average annual yields of the 1st Line riments. The overall averages indicate the early bearing apparently the continuous build-up of yield from 3-6 years ge. The early bearing would have been even more obvious if Tobago, San Jose and El Toco plots had been recorded in /6. In the following year they yielded 20 per cent. more the other plots and their inclusion would presumably have

TABLE 3

Ranking of Experimental Sites for suitability to Cocoa Production

Site	Soil Type	Yield per Acre 1st Line	Percentage of Original Trees Surviving	Index of Standard of after Cultivation	Rank of Suitab
Trinidad Clays					
El Rosario	Talparo Clay	193	90	4	13
Poole Syndicate	Princes Town Heavy Clay	532	98	1	9
San Francisco	Brasso Clay	285	79	2	12
San Jose *	Montserrat Clay	363	88	1	7
Santa Severa	Brasso Clay	389	85	1	11
Trinidad Other Soils					
Arethuse	Moruga Loam	444	88	2	9
El Toco	Calcareous Schist	261	47	3	14
River Estate	R.E. Fine Sand	988	91	1	3
Tobago Soils					
Campbellton	Calcareous Schist	830	89	2	4
King's Bay	Diorite Igneous	797	85	2	5
Louis d'Or	Alluvial	1278	91	1	2
Richmond +	Alluvial	1480	97	3	1
Studley Park	Diorite Igneous	705	83	2	6

* 1 year younger; yields refer to 4 and 5 years not 5 and 6 years of age; acount has been taken of this fact in the final ranking.

\+ Manurial comprising ICS 1 and 95 only; yield however probably comparable with clonal trials.

TABLE 4

Annual Yields of 1st Line Clonal Experiments
(Lb. dry cocoa)

Site	1955/6 3 years	1956/7 4 years	1957/8 5 years	1958/9 6 years
rinidad Clay Soils				
El Rosario	212	431	213	203
Poole Syndicate	175	562	382	683
San Francisco	112	281	227	342
San Jose *	x	169	399	459
Santa Severa	63	169	343	436
Mean	140	322	313	425
inidad Other Soils				
Arethuse	87	306	331	557
El Toco	x	206	277	246
River Estate	131	531	999	978
Mean	109	347	536	594
bago Soils				
Campbellton	x	937	471	1169
King's Bay	x	369	654	940
Louis d'Or	x	556	977	1578
Studley Park	x	481	693	717
Mean	x	586	699	1101
erall Mean	130	416	497	693

* 1 year younger than other experiments (4 and 5 years)

x Not recorded

increased the 1955/6 average to about 156 lbs. per acre. The apparent progressive increase in yield over these four years is not characteristic of all the experiments. Indeed, had Campbellton and Louis D'Or not achieved very large increases from the 5th to the 6th year, the overall increase of 200 lbs. would not have been apparent. A scrutiny of the individual experiments rather suggests that certain of them are already approaching their maximum yield. These are River Estate, Studley Park, El Toco and El Rosario.

Although 6 years of age may appear a very tender age for a cocoa field to reach its maximum, it must be remembered that the 9' x 9' planting is now regarded as unsatisfactorily close particularly when permanent shade is used. It is quite possible that the yield of some of these experiments is being limited by the over-dense shade and over-dense cocoa canopy; (the exception of course is El Toco where the main limiting factor is the very poor stand of original trees). This supposition that over-dense foliage is limiting yield is corroborated by the manurial experiment at Richmond. The magnificent natural conditions of this site have led to extraordinary vigour and rapid development of the young trees which, coupled with generally inadequate pruning, has led to overshaded conditions. The yield of this experiment has remained virtually unchanged at 1,400 lbs. per acre for the last three years.

The experiments that show some evidence of continuously rising yield are not confined either to good or poor sites. For instance, Louis D'Or has been continuously increasing by large leaps whereas Santa Severa at about one-quarter the yield has also been increasing continuously on a more modest scale. It will be seen from the subsequent sections of this paper that the yield analyses have been carried out on the average of two years' yields, 1957/8 and 1958/9, when all experiments excluding San Jose were 5 and 6 years of age respectively.

Pod Size

The weighings of wet beans at River Estate and Poole Syndicate experiments allow the calculation of pod weights which were used in estimating yields for other experiments (Table 5). In all, 46 clones appeared in the two lines of experiments; the remaining 6 clones were put in at an average pod weight of 145 grams wet beans or 7.8 pods to the lb. dry. As would be expected from the basis of selecting the Imperial College clones

TABLE 5

Average Weight of Pods

(Av. Weights River Estate and Poole Syndicate 1956/7)

ne	Grams wet beans	Pods to 1 lb. dry	Clone	Grams wet beans	Pods to 1 lb. dry	Clone	Grams wet beans	Pods to lb. dry
1	145	7.8	ICS 47	150	7.5	ICS 95	119	9.5
6	180	6.3	48	168	6.7	98	123	9.2
8	175	6.5	49	153	7.4	100	148	7.6
9	140	8.1	53	142	8.0	E 660	170	6.6
16	160	7.1	60	172	6.6	GS 36	132	8.6
22	145	7.8	61	180	6.3	IMC 57	97	11.6
32	137	8.2	70	146	7.7	67	141	8.0
35	170	6.6	73	138	8.2	SP 1	112	10.1
37	154	7.3	75	138	8.2	P 7	152	7.4
38	170	6.6	79	132	8.6	P 18	155	7.3
39	164	6.9	84	121	9.3	PA 30	111	10.2
40	167	6.8	85	162	7.0	PA 46	145	7.8
43	195	5.8	87	152	7.4	121	129	8.8
44	136	8.3	89	135	8.4	150	131	8.6
45	148	7.6	90	136	8.3			
46	155	7.3	91	171	6.6			

these have generally larger pods than the others and considerably larger than the average of open pollinated Trinitario seedlings (about 10 pods to the lb.). With the exception of IMC 57 all these clonal pods are large by Amazon and even Trinitario standards.

Witches' Broom Resistance

Witches' Broom disease was observed to a varying degree on different experiments. For instance, at the young age of 2 years vegetative brooms were reported as being numerous on the Studley Park site. Consequently a special count was made on the 1st Line experiment in May, 1955, of vegetative brooms and the results were analysed statistically. It was found that in fact there was an average of only 1 broom per 10 trees and that only ICS 43 with 1 broom for every 2 trees showed significant susceptibility. ICS 40 (1 broom to 4 trees) and ICS 75 (1 broom to 3 trees) were the only other two clones which showed any differential susceptibility.

The Poole Syndicate site is in a generally bad Witches' Broom area and data is available for the actual number of broom pods harvested. These experiments therefore give a basis for reviewing the susceptibility of various clones to pod loss through this disease. However, the incidence varies considerably from year to year according to season; for instance, in the 1st Line experiment on this site in 1957/8 only 2 per cent. of the pods were infected whereas in 1958/9, 13 per cent. were infected. The analysis given in Table 6 has therefore been carried out on the 1958/9 crop.

If the clones are grouped into three levels of infection, i.e. under 10 per cent. - Unsusceptible; 10 per cent. to 19 per cent. - Intermediate; 20 per cent. and over - Susceptible, the following observations can be made. The Unsusceptible ICS clones are 1, 6, 22, 35, 45, 46, 47, 49, 53, 61, 85 and 95; the Intermediate ones are 9, 32, 38, 39, 40, 43, 48, 60, 70, 73, 75, 84, 91 and 100; the Susceptible ones are 8, 37 and 89. Of the P clones, 18 is Intermediate and 7 is Susceptible. All three PA clones in this experiment appear to be Unsusceptible as also is the solitary SP clone. IMC 67 is Intermediate.

The pod loss percentages must of course be read in the later context of yields in assessing the worth of clones. For instance, the apparent complete resistance of ICS 6 is of little commercial interest (though it may be of great interest genetically) because this clone yielded the least over all first line experiments and virtually nothing on this experiment at 6 years of age. By contrast, PA 150 which had a percentage of infected pods not significantly greater than ICS 6 yielded 984 lbs. per acre on this experiment.

TABLE 6

Percentage of Pods infected with Witches' Broom
Poole Syndicate 1959.

st Line Clonal Trial		2nd Line Clonal Trial	
ne	% Witches' Broom Pods	Clone	% Witches' Broom Pods
1	3	ICS 9	18
6	0	22	7
8	22	35	3
32	12	37	22
39	13	38	11
40	15	45	9
43	13	49	4
46	5	53	8
47	3	70	13
48	13	73	10
60	10	85	6
61	8	91	11
75	13	SP 1	6
84	19	P 7	20
89	20	18	9
95	4	PA 30	0
100	11	PA 46	0
67	13	121	4
		150	3
n	9		8
st Sig. ference 5%	3		4

1st Line Clonal Yields

Table 7 gives the mean yields from all experiments and the yields divided into the broad soil types, Trinidad Clays, Other Trinidad, and Tobago Soils; Appendix 2 lists the yields on all experiments.

There can be no doubt that although these clones were selected as the heaviest bearers known in 1950, they vary widely in performance on these experiments, from 931 lbs. per acre by ICS 40 to only 325 lbs. for ICS 6. Any errors that may arise from the method of estimating these yields are not likely to invalidate such major clonal differences. Further, although the experimental errors for individual experiments were found to be large (Standard Error about 30 per cent. of the mean yield) this error on the combined results is tolerably low. From the combined figures it can be said that there are 8 very productive clones giving more than 650 lbs per acre; 5 moderate bearers, between 450 and 649 lbs.; the remaining 6 do not, at least at their present age, give much promise of good yields.

There is a significant difference in the overall yield of experiments grouped by the three Soil Types. Differences in these means of only 40 to 45 lbs. an acre were required for significance at the 1% level; thus Trinidad Clays are definitely inferior to the other two soil types and Tobago Soils are superior to the Trinidad Other Soils. The low productivity of Trinidad Clays suggest that these soils are of doubtful suitability for profitable long term cocoa production. The greatest hope of profitable cultivation on these soils seems to be in the severe restriction of the range of clones planted only to those which appear to be particularly tolerant to the inferior soil conditions. Out of those tested, three clones appear to be outstanding in this respect, i.e. IMC 67, ICS 95 and ICS 40.

The clones that give good yields on Other Trinidad Soils appear to be generally suited to Tobago conditions as well. The most productive of these are ICS 39, 40, 43, 48 and 60. The exceptions to this similarity seem to be IMC 67 and ICS 89 which appear to be definitely less suited to Tobago conditions than the Other Trinidad soils. At a much lower level of yield ICS 1 seems to be less suited to Other Trinidad Soils than to Tobago where it bears as heavily as ICS 95.

TABLE 7

Clonal Yields 1st Line Experiments by Soil Groups.
(1957/8 and 1958/9, dry lbs. per acre per annum)

ıe	Trinidad Clays Yield	Rank	Trinidad Other Yield	Rank	Tobago Yield	Rank	Mean Yield	Rank
1	211	14	391	16	895	10	484	13
6	29	19	335	19	688	15	325	19
8	192	16	420	15	746	12	434	14
32	221	13	347	17	673	17	403	16
39	451	5	850	3	1281	1	827	2
40	606	3	1016	1	1274	2	931	1
43	417	10	660	6	1126	5	714	6
46	316	12	632	7	1051	7	640	10
47	436	9	582	10	957	8	646	9
48	450	6	764	5	1236	4	790	5
60	447	7	788	4	1272	3	807	3
61	392	11	614	9	1123	6	691	8
75	519	4	460	12	689	14	560	11
84	188	17	434	13	700	13	420	15
89	443	8	485	11	584	18	500	12
95	626	2	631	8	886	11	713	7
98	186	18	344	18	679	16	390	17
00	195	15	422	14	540	19	367	18
67	630	1	913	2	904	9	792	4
	353		564		902		589	
t Sig. erence (5%)	115		172		236		101	

The clones x experiment interaction proved to be clearly significant at 1% probability indicating that a number of clones reacted markedly to different conditions. Calculations were therefore made to compare the expected yield based on the average for the clone and the experiment concerned with the actual yield. Of the 10 highest yielding clones in Table 7 (ICS 39 to IMC 67 plus ICS 95) all showed certain differences between expected and actual yield far greater than would be likely to occur by chance. The smallest difference required for significance at 1% was 125 lbs. per acre whereas many differences exceeded 300 lbs. per acre. The general conclusions that can be drawn from this interaction table are as follows: ICS 39 through to ICS 61 showed similar characteristics generally in yielding less than would be expected on the clay soils and more than would be expected on the Tobago experiment. The most variable clones in this group are ICS 39 and ICS 48. ICS 39 yielded 706 lbs. an acre more than expected on Louis D'Or and 328 lbs. less than expected on Poole Syndicate indicating probably its sensitivity to drainage and perhaps phosphate status of the soil; ICS 48 +592 lbs. per acre on King's Bay and -292 lbs per acre on San Francisco indicating probably the same sensitivity but under more exposed conditions. The least variable clone in this group was ICS 60 which yielded generally close to expectation on various experiments.

IMC 67 and ICS 95 exhibited reverse characteristics, yielding generally higher than anticipated on Trinidad Clays and lower than expected on Tobago (see above). IMC 67 was, however, exceptional in yielding 430 lbs. more than expected on El Toco, a well drained, exposed and generally undershaded site, a complete contrast to Trinidad Clays. The reason for this exceptional performance is not clear; it cannot be the open exposed conditions because the clone did comparatively poorly on the exposed Campbellton and Arethuse sites; or to the very abundant Phosphate and Potash on the El Toco site because of the relative poor performance in Tobago, well endowed in these respects, and the very average yield on San Jose, the other Trinidad site with high P and K analyses. ICS 95 is a much more predictable clone; it yields consistently better than would be expected on Trinidad Clays, and worse on Tobago soils. The yields appear to be correlated with soil pH; this clone produces generally more than would be expected on acid soils with pH of less than 6.0.

Of the lower yielding clones, ICS 75 gave exceptional results (485 lbs. an acre above the expected) on Poole Syndicate, where this generally mediocre clone on this medium yielding experiment gave an estimated yield of no less than 1,354 lbs. per acre. On other experiments this clone was not particularly variable and it is difficult

explain its extraordinary productivity on this single site unless
is in some way connected with the high Organic Matter content
/or the high potash recorded in the analysis of this soil.
89 is the only other moderate yielding clone that shows any marked
ponse to conditions and appears to do consistently better than ex-
ted on Trinidad Clays and distinctly worse than expected on Tobago
eriments.

Line Experiments

Table 8 shows that there were only six clones including
control, ICS 95, that appeared in all experiments and another six
t appeared in all experiments in two soil groups. The general
el of yield is rather lower, particularly in Tobago, than for the
Line experiments. This difference seems to be due more to inferior
nes than to the inferiority of the sites and their cultivation. It
be seen that the control, ICS 95, gave substantially the same yield
both 1st and 2nd Line experiments.

Of the clonal yields it can be said that ICS 95 was of a
ndard equal to the best of this miscellaneous collection. No other
ne in any soil group outyields ICS 95 by a significant margin. In
individual experiments, however, (see Appendix 3) ICS 95 was out-
lded by a margin of more than 100 lbs. per acre by some clones;
se are summarised in Table 9.

It is clear from this Table that none of the 2nd Line col-
tion of clones is exceptionally good or up to the standard of the
y best in the 1st Line. The best 2nd liners are about equal to
95 which in the 1st Line experiments was ranked as 7th of the 19
nes. However, with the exception of PA 218 and PA 46, all the others
probably worth propagating to amplify the range of planting material.
ls probable also that at least three of these clones are of some
rest for breeding work particularly P 7 with a large pod (7.4 to the
), though apparently susceptible to Witches' Broom; P 18 with a
llar large pod and unsusceptible as regards Witches' Broom; PA 150
a rather smaller pod (8.6 to the lb.) and insusceptible to Witches'
om.

rial Experiments

These experiments have given generally disappointing results.
of 33 annual analyses which allow the examination of 198 possible
rial responses, only 11 proved significant usually at the 5% level;
possible 84 Fertiliser x Clone interactions, only 6 proved signi-
nt. The infrequency of significant responses (one in sixteen)

TABLE 8

Clonal Yields 2nd Line Experiments by Soil Groups
(1957/8 and 1958/9, Dry lbs. per acre per annum).

Clone	Trinidad Clays Yield	Rank	Trinidad Other Yield	Rank	Tobago Soils Yield	Rank	Mean Yield	Rank
ICS 22	82	6	178	6	458	4	211	5
37	237	3	379	4	637	3	385	3
45	94	5	183	5	369	6	193	6
95	528	2	872	2	843	1	708	2
P 18	568	1	936	1	839	2	742	1
PA 30	220	4	565	3	421	5	369	4
Mean	247		445		510		373	
Least Sig. Diff. (5%)	117		192		234		98	
ICS 9	121		57		-			
16	-		428		-			
38	-		291		261			
73	-		-		423			
85	59		-		255			
87	-		-		622			
91	163		-		-			
IMC 57	-		-		513			
PA 39	-		-		605			
46	241		-		553			
118	-		-		570			
121	501		-		741			
150	485		-		846			
169	-		-		802			
218	-		-		696			

Other Clones Averaging more than 400 lbs. per acre per annum

Clone	Yield	No. of Experiments
ICS 90	553	1
GS 29	837	1
36	774	2
P 7	880	3

TABLE 9

Clones Outyielding ICS 95 by more than 100 lbs. per acre per annum in Individual Experiments.

No. of Expts. with both Clones	No. of Expts. clone out-yielded ICS.95 by +100 lbs.	Average Yield in Experiments containing both clones	
		Clone	ICS 95
1	1	837	553
3	2	787	614
11	6	742	708
10	4	678	684
8	3	736	654
9	3	590	586
10	2	669	685
7	1	419	640
10	1	369	689

TABLE 10

Yields of Fertiliser Plots (Lb. per acre per annum) 1957/8 and 1958/9

	Nitrogen		Mean	Potash	
	Without	With		Without	With
Without	538	594	566	558	574
With	623	595	587	587	631
Mean	580	595	593	573	602
Without	563	582	L.S.D. (P 5%)		
With	598	607	Main Treatments 46 lb. per ac.		
			Cells of tables 65 " " "		

rather suggests that many of them are the 1 in 20th chance and do not reflect any real fertiliser response. The only clear result that has emerged from these fertiliser experiments is that clone ICS 95 outyields ICS 1 except on a few Tobago sites, a fact which is already known from the clonal experiments.

There does, however, seem to be a tendency for responses to become less infrequent as the fields increase in age; for instance 6 significant fertiliser responses (some at 1%) out of a possible 54 were recorded in 1958/9 when the experiments were 6 years of age. The effect of these fertilisers may be cumulative, but, even if they are, it will take many years and much larger responses in future to make the past expenditure on fertiliser profitable.

The mean fertiliser treatment yields are given in Table 10. There are obviously positive differences associated with the application of each of the fertiliser ingredients but they are too small to be significant even in such a statistically precise combination of so many experimental results. Even if the significance of the differences could have been established there is little chance of increases of this order ever being profitable. For instance, an application of ½ lb. of Sulphate of Ammonia per tree would cost in the order of $20 an acre and would therefore require an increase of at least 50 lbs. of dry cocoa per acre to pay the cost.

It is interesting to note that on two of the least productive Trinidad Clays (El Rosario and San Francisco) phosphate gave significant responses over the two years, 1957/8 and 1958/9. A similar response was also recorded for Campbellton, (the manurial experiment is situated on an eroded, exposed section of the site) also a phosphate deficient soil. Although these experiments yielded poorly, the proportional response to phosphate is generally large and the absolute response, quite significant (Table 11). In view of the fact that Superphosphate was applied to the surface it is interesting to speculate what might happen on these poor soil conditions if it was incorporated in the soil and had the chance of being more effective. Perhaps the incorporation of phosphatic fertiliser in the original planting holes might have altered the productivity of these fields considerably. However, it is not wise to become too optimistic about these results; it must be remembered that the present yields even with phosphate are really too low to ensure profitable cultivation of the fields.

The clearly negative conclusion indicates that under the conditions of these experiments (commercial cultivation, over-close

TABLE 11

Phosphate Response on
Three Selected Experiments

Site	Without Phosphate	With Phosphate	Response	Least Sig. Diff. (at 5%)	Average Yield
Rosario	235	289	+ 54	38	262
Francisco	175	312	+ 137	82	244
pbellton	338	480	+ 142	103	409
Mean	249	360	+ 111	46	305

nting and often overshaded canopy) single annual fertiliser appli-
ions to bearing cocoa as a routine maintenance operation are not
ely to be profitable on a commercial estate. This conclusion does
of course exclude special cases and special treatments. For in-
nce, it has been reported[6] on an estate experiencing great diffi-
ty in maintaining their permanent shade that applications of nitro-
keep the trees vigorous under exposed conditions. Larger manurial
ponses have been reported elsewhere on River Estate.[7] Further-
e, it is to be expected that applications of various kinds of ferti-
ers to temporary ground shade during the first year of replanting
rations would increase the vigour of the cover and generally improve
fertility of the soil and the general conditions of the field for
oa planting.

SUMMARY

1. The results of 32 clonal and manurial experiments situated on various soil types mainly on commercial plantations in Trinidad and Tobago were reported. The experiments consisted of three types: (a) 12 first line clonal experiments containing comparisons of 19 clones consistent between experiments; (b) 11 second line experiments, inconsistent between experiments and in total testing 35 clones; (c) 9 fertiliser experiments with consistent fertiliser treatments on every site.

2. The practical difficulties of conducting experiments involving yield recording on commercial cocoa farms are discussed. The method of yield recording used is explained.

3. The soil, ecological and management conditions of various experimental sites were examined.

4. The characteristics of the clones under trial as regards pod size and resistance to Witches' Broom were examined.

5. Very significant differences in yield were to be observed between the clones in the carefully selected first line trials. The variability of individual clones from one site to another was also examined.

6. Nine clones of Amazonian origin including IMC 67 have outyielded ICS 95, the best general all-purpose ICS clone, at 21 experimental sites (Table 9).

7. Fertilisers gave very infrequent responses that could be proved statistically significant. The responses that were observed were generally too small or occurred on fields where the yield was too low to make these applications profitable under the conditions in which the cocoa was grown.

RESUMEN

1. Se informa sobre los resultados de 32 comparaciones clonales y ensayos de fertilizantes sembrados en distintos tipos de suelo en fincas comerciales en Trinidad y Tobago. Hay tres tipos de experimentos: (a) 12 experimentos de clones de primera clase, cada uno con los mismos 19 clones, (b) 11 experimentos de clones de segunda clase, incluyendo un total de 35 clones diferentes y (c) 9 experimentos de fertilizantes.

Se discute las dificultades prácticas relacionadas con la toma de datos en experimentos de fincas particulares, y se describe el método usado.

Se examina las condiciones ambientales y el nivel de mantenimiento en los experimentos diferentes.

Se observa las características de los clones con respecto al tamaño de mazorca y resistencia a Escoba de Bruja.

Se encontró diferencias altamente significativas en rendimiento entre los clones de los experimentos de primera clase. Se estudia la variación en rendimiento entre los clones individuales según su ubicación.

ICS 95 resultó ser el mejor de los clones ICS tomando en cuenta su comportamiento en todos los 21 sitios donde fue sembrado, pero nueve clones de origen amazonas, incluyendo el IMC 67, lo sobrepasaron en rendimiento.

El uso de fertilizantes muy pocas veces dió respuestas significativas con respecto a la producción. Los aumentos que sí se notó fueron muy limitados, u occurrieron en experimentos con rendimientos demasiado bajos, de manera que la aplicación de fertilizantes no podía considerarse económicamente justificada.

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APPENDIX 1

Certain Soil Characteristics of Experimental Sites (generally at 3")

	% Non Sand	Cap. Pore Space %	Non Cap. Pore Space %	Index Texture	pH	C/N Ratio	O.M. %	Available P_2O_5 p.p.m.	Available K_2O p.p.m.
Trinidad Clays									
El Rosario	76	48	2	38	5.2	7.6	3.9	19	87
Poole Syndicate	87	45	22	62	6.3	8.5	6.4	22	148
San Francisco	79	56	-	48.	5.0	7.7	3.7	13	23
San Jose	91	48	9	50	7.4	10.3	4.9	300	153
Santa Severa	66	44	(-3)	29	5.7	7.6	3.0	5	105
Trinidad Other Soils									
Arethuse	57	36	18	31	4.5	8.1	2.5	18	92
El Toco	62	-	-	28	6.4	7.5	4.6	153	104
River Estate	55	38	22	36	5.6	9.3	3.5	17	43
Tobago Soils									
Campbellton	67	46	10	38	6.3	9.2	4.3	12	53
King's Bay	40	30	23	22	6.7	9.4	3.5	113	79
Louis d'Or	47	30	24	22	6.5	11.2	2.8	125	33
Richmond	50	32	19	28	6.3	10.8	4.1	69	66
Studley Park	67	46	13	42	6.6	10.6	4.8	78	71

Yields of all 1st Line Clonal Experiments
(Lbs. per acre per annum) 1957/8 and 1958/9.

CLONE	El Rosario	Poole Syndicate	San Francisco	San Jose*	Santa Severa	Arethuse	El Toco	River Estate	Campbell-ton	King's Bay	Louis D'Or	Studley Park
ICS 1	150	372	164	96	273	193	134	847	722	692	1107	1060
6	6	0	48	71	18	288	27	689	572	616	1099	463
8	124	581	110	42	104	284	74	901	751	421	952	859
32	115	491	166	79	257	191	78	771	713	550	878	553
39	288	443	263	572	687	706	576	1268	908	1281	2223	714
40	435	573	377	777	868	589	837	1623	1364	1028	1828	874
43	205	349	364	642	527	519	394	1068	1220	865	1597	823
46	136	313	270	442	422	592	153	1154	1083	1159	1293	669
47	98	495	409	610	571	449	244	1054	702	784	1710	631
48	256	564	195	708	526	608	339	1346	1024	1590	1605	725
60	239	564	367	474	592	939	292	1132	1061	1308	1628	1091
61	272	283	388	698	320	539	236	1066	1216	1070	1536	669
75	220	1354	330	285	408	499	271	611	625	616	1023	491
84	97	306	94	175	268	327	137	837	717	760	879	442
89	333	830	371	178	503	299	110	1046	737	266	1054	281
95	396	829	675	444	785	702	320	870	758	653	1155	976
98	57	406	213	138	117	471	46	516	439	773	1129	376
100	97	407	162	250	60	373	43	851	566	279	807	506
IMC 67	273	1063	707	614	491	355	895	1489	817	745	1241	814
Mean	193	532	285	363	389	444	261	988	830	797	1278	705
Least Sig. Diff. (5%)	171	270	253	316	249	222	282	370	396	570	478	431

* 1 year younger (4 and 5 years) than other experiments.

APPENDIX 3

Yields of all 2nd Line Clonal Experiments
(Lbs. per acre per annum) 1957/8 - 1958/9.

CLONE	El Rosario	Poole Synd.	San Francisco	San Jose	S.Severa	Arethusa	El Toco	River Estate	Campbellton	Louis D'Or	Studley Park
ICS 1	-	-	-	-	-	-	-	-	249	1100	695
9	0	181	93	296	34	0	54	117	-	-	-
16	-	-	-	-	-	420	291	574	-	-	-
22	69	222	43	28	48	152	204	179	174	944	256
35	-	163	-	-	-	-	330	307	-	-	-
37	114	240	448	224	157	319	387	593	437	1178	296
38	151	388	277	-	55	59	342	471	178	443	164
44	-	-	-	-	-	-	50	458	-	-	-
45	23	166	94	137	51	189	176	183	242	624	242
49	-	203	-	-	-	-	421	477	-	-	-
58	-	463	-	-	-	-	292	389	-	-	-
70	100	294	180	-	68	206	-	680	233	872	-
73	227	760	-	-	214	550	443	-	146	797	356
85	30	37	50	131	46	205	361	-	111	394	261
87	-	-	299	421	0	224	569	-	392	1091	382
90	-	-	-	-	-	-	-	553	-	-	-
91	99	209	253	223	30	-	239	-	-	-	-
95	495	844	502	553	245	912	765	940	512	1246	771
E 660	-	-	-	100	-	-	177	269	-	-	-
DS 1	-	-	-	378	-	-	-	-	-	-	-
9	-	-	-	391	-	-	-	-	-	-	-
GS 29	-	-	-	837	-	-	-	-	-	-	-
36	-	-	-	617	-	-	-	931	-	-	-
IMC 57	349	-	736	586	559	393	-	1148	332	746	460
SP 1	-	91	-	-	-	-	-	212	-	-	-
P 7	236	1268	856	-	-	-	-	-	-	-	-
18	225	700	1096	499	318	553	1029	1225	276	1360	880
PA 30	159	246	311	150	236	384	414	896	306	767	190
39	304	-	453	-	178	845	-	-	202	1123	491
46	44	149	269	717	25	207	620	-	211	816	631
118	-	-	504	-	41	580	-	-	214	1070	427
121	253	727	550	569	406	901	1057	-	428	1115	680
150	198	984	549	288	406	790	1031	-	351	1430	756
169	323	-	708	648	637	1166	-	-	454	1097	856
218	-	-	352	-	36	358	-	-	185	1403	500
Mean	169	421	411	375	180	446	441	562	277	991	478
Least Sig. Diff. (5%)	138	266	348								

NOTA SOBRE LA SENSIBILIDAD DEL CACAO A LAS RADIACIONES GAMMA Y SU RELACION CON EL DAÑO CAUSADO EN EL NUCLEO CELULAR *

Fernando Monge S. **

Uno de los problemas de actualidad entre los radiobiólogos s la diferente sensibilidad a las radiaciones existente entre rganismos afines. Una investigación preliminar sobre la radiosnsibilidad de semillas de libre polinización de cinco cultivas de cacao: UF-613, UF-221, UF-676 (clones seleccionados por United Fruit Co.), CC-40 (clon de la selección del IICA) y tina (tipo local de cacao), demostró que las semillas procedens de los clones UF presentaban mayor resistencia a las radiaones que las semillas de CC-40 y Matina, usándose como criterio evaluación el porcentaje de supervivencia y la altura del hipotilo. La diferencia en estos dos grupos fue altamente significativa. Se hizo entonces, un estudio entre las semillas del culvar más resistente, UF-613 y las del más sensible, Matina. Se contró que las curvas de supervivencia para ambos cultivares an de tipo sigmoide. De este hecho se dedujo que la acción morl de la radiación no se debía a impactos simples (una ionizaón o una partícula ionizante) sino a una acumulación de dos ó s impactos. Las dos curvas diferían principalmente en su grante.

Por la interpolación se calculó que la DL_{50} (Dosis que cau efecto letal en el 50% de los organismos) para Matina estaba rededor de los 7.500 r, mientras que para UF-613 era de 9.500 r, roximadamente. La altura del hipocotilo tomada como indicador l crecimiento, también demostró que en Matina el efecto de la diación era más drástico que en UF-613. Observaciones citológis hechas en puntas de raíz mostraron que la mayor sensibilidad Matina estaba relacionada con una mayor frecuencia de puentes omáticos observados en anafase.

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* Trabajo efectuado bajo contrato cooperativo entre el IICA y la Comisión de Energía Atómica de los EE.UU. de Norteamérica (No.AT(30-1)-2043).

** Asistente graduado, Proyecto de Energía Nuclear del Departamento de Fitotecnia, Instituto Interamericano de Ciencias Agrícolas, Turrialba, Costa Rica.

Estudios preliminares sobre el efecto del fraccionamiento de la dosis demostraron que a 2.000 r, la recuperación de Matina tuvo lugar dentro de un período de 2 horas, mientras que en UF-613 solamente se observó una recuperación no significativa dentro del mismo período de tiempo. Si este hecho implica una diferencia en actividad metabólica, podría ser un indicio para explicar la diferente sensibilidad presentada por Matina y UF-613. Sin embargo, al no haber evidencia directa que pruebe este punto, solamente especulaciones caben al respecto.

RESUMEN

Experimentos preliminares con aplicacion de diferentes dosis de rayos gamma demostraron que habían diferencias en sensibilidad a la radiación en diferentes cultivares de cacao. La variedad más sensible fué el amelonado "Matina" y la menos sensible las progenie de semilla del clon UF 613. Observaciones citológicas indicaron qu la sensibilidad a la radiación estaba relacionada directamente con la frecuencia de puentes cromáticos. Trabajos con dosis fraccionad indican diferentes tiempos de recuperación entre los dos cultivares Se ofrecen posibles explicaciones.

SUMMARY

Preliminary experiments on the application of different doses of gamma rays to cacao seed showed that different cultivars vary in the sensitivity to the radication. "Matina" was the most sensitive variety and seed from UF 613 the least. Cytological observations indicated that sensitivity was directly related with the frequency of chromosome bridges. Experiments using fractionated dosages showed that different cultivars vary in the time for recuperation. Possible explanations of the phenomena are suggested.

SUMMARY OF DISCUSSION

A.J. Hansen (IAIAS)

The curves you showed show a difference of DL 50 between 613 and Matina cacao of about 32%. You also mentioned that difference between the two types is highly significant. This ld indicate there is very little variation in regard to sus-ibility within your open pollinated F1 of the UF 613 and Ma- groups. In other words, the more resistant UF 613 produces ry high percentage of more resistant F1 seedlings. How do explain this, in view of the fact that many other character-cs of cacao, such as yield, seem to be inherited to only a degree, especially after open pollination?

J. Soria (IAIAS)

I can explain the difference between the sensitivity of na and UF 613. I think that Matina cocoa is very uniform in characteristics; probably it is homozygous. On the other open pollinated seed from UF 613 is heterozygous for many acteristics. Something that should be pointed out here also hat we cannot necessarily expect to obtain mutations in the t generation. We have to wait a further generation to see result. Unfortunately, the probability of obtaining favour- mutations is extremely low, as was said by Monge. The use adiation in plant improvement is only an additional method the breeder, but we cannot place too much hope in it because he low probability of obtaining favourable mutations.

C. Navarrete (Venezuela)

In the programme are you going to radiate seedlings, and at age?

F. Monge (IAIAS)

We are already irradiating seedlings.

Dr. J. Soria (IAIAS)

The radiation has been done with different doses on young plants that are about 15 days old. More work has been done in radiating seeds because it is easier to do so. We have planted these seedlings in the field. We have planted about one thousand but only a few seeds show any clear mutation. In the beginning we observed that the first cotyledon leaves are highly deformed but later new leaves have normal form.

Ing C. Navarrete (Venezuela)

Could anyone explain to us the objective of this project?

Ing. F. Monge (IAIAS)

This is a question on which we could probably write a book. We could say that radiation is just another way to improve the genetic material and to obtain beneficial mutation - that is the practical objective. We are also conducting cytological studies on the irradiated material, with particular reference to chromosome damage, and thus advancing our knowledge of the cytology of cacao.

SUR LES TRAVAUX DE RECHERCHES EFFECTUES EN 1959 A LA STATION DU CACAOYER DE N'KOEMVONE POUR LA PRODUCTION DES SEMENCES SELECTIONNEES DE CACAOYERS (CAMEROUN)

J. Liabeuf*

RESUME

Parallèlement à ses travaux concernant la multiplication végé-.ve du cacaoyer et la distribution de boutures, commencés en 1952)53, la Station du Cacaoyer de N'Koemvone a entrepris en mars 1959 travaux relatifs à la production des semences selectionnées de ıoyers. Ce travail est possible grâce à la possession d'un maté-. clonal à la fois varié et suffisamment âgé. Le programme de sé-ion par multiplication sexuée comporte autofecondation et hybri-.on.

Etude de la compatibilité des clônes de sélection locale les plus intéressants

Parmi les 476 clônes à l'étude, 14 seulement ont, jusqu'ici, fait l'objet de tests d'autocompatibilité: douze sont d'origine locale et deux sont des descendants de première génération de cacaoyers Upper Amazon en provenance du Ghana. Parmi ces 14 clônes, 4 sont autocompatibles, les 10 autres presentent des degrés divers d'autoincompatibilité, ainsi que le montre le tableau ci-dessous:

Nombre du clône		Nombre d'opération	Nombre de cabosses obtenues Total	Wiltées après 15 jours	Recoltées
SNK	10	19	0	0	0
	12	43	6	3	3
	13	19	0	0	0
	16	11	0	0	0
	37	26	19	10	9
	48	7	0	0	0
	52	15	0	0	0
	64	34	19	3	16
	109	6	0	0	0
	111	20	0	0	0
UPA	134	22	0	0	0
	143	20	0	0	0
SNK	178	21	0	0	0
	344	13	8	4	4

irecteur de la Station du Cacaoyer de N'Koemvone, République du ameroun.

2. Etude de la première génération sexuée des clônes autocompatibles

Les cabosses résultant des autofecondations artificielles ont été recoltées et leurs caracteristiques répérés avec soin, les fèves ont été semées en pots et les seedlings obtenus seront mis en place en séptembre 1960.

3. Programme d'hybridation

La Station de N'Koemvone possède trois types de cacaoyers:

- les sélections locales (SNK)
- les sélections de l'Imperial College of Tropical Agriculture, Trinidad (ICS)
- des descendants de cacaoyers Upper Amazon provenant du Ghana.

Le principe étant de realiser des croisements par pollinisation naturelle d'un clône autoincompatible choisi comme mère avec un autre clône choisi comme père, les croisements possibles sont:

SNK autoincompatible x SNK
SNK autoincompatible x ICS
ICS autoincompatible x SNK
Upper Amazon x ICS

Les hybrides de première génération FI seront plantés et suivis en plantation. Les meilleurs sujets de la FI seront repris pour effectuer de nouvelles hybridations.

Avant d'avoir la possibilité d'établir les plantations isolées où se feront ces hybridations par pollinisation naturelle, des hybridations par fecondations artificielles sont dès maintenant effectuées. Le programme d'hybridation a été assez limité en 1959; il était d'abord necessaire de connaître, grâce aux tests d'autocompatibilité, les clônes susceptibles d'être utilisés.

Actuellement 131 cabosses ont été obtenues des diverses pollinisations artificielles effectuées, dont le detail est donné dans le rapport complêt resumé ici.

Création de champs semenciers provisoires

Le programme d'hybridation tel qu'il est décrit ici suppose qu'avant la mise en place de champs semenciers définitifs, les hybrides obtenus soient parfaitement connus, ce qui porterait très loin dans le temps, la création de ces champs semenciers.

Aussi, en même temps que seront suivis ces hybrides, des champs semenciers provisoires seront mis en place, qui pourront fournir des semences dès 1965.

SUMMARY

The N'Koemvone Experiment Station began production of selected
d in 1959, including selfed seed and crosses, in addition to the
vious work on vegetative propagation and the distribution of rooted
tings begun in 1952 and 1953.

1. Of 476 clones, only 14 have been tested for self-incompatibility; 12 local and 2 first generation progeny of Upper Amazon clones from Ghana. Only 4 of the 14 clones are self-incompatible.
2. Self-pollinated progeny of clones are to be subjected to field trials in 1960.
3. The three types of cacao available at N'Koemvone are local selections (SNK), ICS selections and seed from Upper Amazon clones from Ghana.

   It is intended to produce hybrid crosses by natural pollination of self-incompatible clones. Up to the present only controlled hand pollinations have been made.
4. Seed gardens will be producing hybrid seed by 1965.

RESUMEN

En marzo 1959, la Estación Experimental de N'Koemvone empezó
bajos relacionados a la producción de semillas seleccionadas,
luyendo semillas auto-fecundadas y cruces, en adición a traba-
anteriores de multiplicación vegetativa y distribución de esta-
enraizadas, comenzados en 1952 y 1953.

1. De 476 clones, solamente 14 fueron sometidos a prueba de auto-incompatibilidad, 12 de origen local y 2 de decendencia de primera generación del Alto Amazonas procedentes de Ghana. De los 14 clones solamente 4 son auto-incompatibles.

2. Las mazorcas conseguidas por medio de auto-fecundación artificial fueron cosechadas y las semillas seran sembradas en una prueba de campo en setiembre de 1960.

3. La Estación de N'Koemvone tiene 3 tipos de cacao:

   - selecciones locales (SNK)
   - selecciones del Imperial College of Tropical Agriculture, Trinidad (ICS)
   - descendientes de cacao del Alto Amazonas, procedentes de Ghana.

   Se está planeando producir cruces híbridos por polinización natural de clones auto-incompatibles. Hasta la presente, se han hecho solamente polinizaciones artificiales controladas.

4. Jardines de semillas producirán semillas seleccionadas a partir de 1965.

PAPERS ON EXTENSION AND DEVELOPMENT

REFORESTACION DE TERRENOS NO APROPIADOS PARA CACAO

Gerardo Budowski *

En muchas regiones donde se cultiva el cacao existen igualmente extensas áreas que por su topografía, baja fertilidad o textura desfavorable del suelo, no son apropiados para el cultivo del cacao. El propietario se pregunta entonces para qué usos se pueden destinar ventajosamente estos terrenos.

La reforestación de especies forestales de valor, que a menudo parece ser el uso más lógico, ha tropezado en la práctica con muchos inconvenientes resultando frecuentemente en fracasos técnicos y económicos.

También la perspectiva de reforestar para cosechar en un tiempo que se estima muy largo ha sido causante del poco interés que se observa hacia el aspecto forestal; en realidad esto no es siempre válido ya que hay una progresiva valorización de la propiedad y en muchos casos los raleos pagan al poco tiempo el costo de la plantación, quedando futuras cosechas como ganancias líquidas.

En los últimos años se ha verificado un cambio de actitud bastante importante hacia la reforestación. Ante todo, el precio de la madera ha aumentado vertiginosamente en muchas zonas cacaoteras debido en gran parte a la merma de los bosques naturales. Hay a menudo mercado para maderas delgadas o postes que se obtienen en los primeros raleos después de pocos años. La técnica forestal también ha hecho progresos vertiginosos. Quizás no sea exagerado decir que en la última década se ha escrito más sobre plantaciones forestales en zonas tropicales calientes húmedas que en todos los tiempos anteriores. De hecho se tienen ahora valiosos datos sobre especies prometedoras y se conocen las razones que explican muchos fracasos. Las técnicas para establecer plantaciones en zonas tropicales han mejorado notablemente, especialmente en cuanto a la economía de las operaciones.

El presente trabajo intenta describir algunos de estos adelantos. Los datos citados se basan más que todo sobre experiencias acumuladas en la América Tropical dentro de zonas climáticas

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* Jefe Interino, Departamento Recursos Renovables, Instituto Interamericano de Ciencias Agrícolas, Turrialba, Costa Rica.

ue se consideran apropiadas para el cacao y que en líneas gene-
ales pueden definirse por una temperatura media anual superior
22ºC y una precipitación media anual de 1800 a 4000 milímetros.

ESPECIES FORESTALES IMPORTANTES EN ZONAS CACAOTERAS

Existe una gran variedad de árboles que se desarrollan muy
ıvorablemente en las zonas cacaoteras. Para que una especie sea
:comendable para los propósitos de reforestación que nos ocupan,
ha estimado que debe poseer las siguientes características de-
:ables: buen mercado para la madera, crecimiento rápido, relati-
tolerancia a suelos malos, relativa resistencia a los insectos,
fermedades y vientos y posibilidad de establecer económicamente
a plantación.

En la enumeración que sigue, se ha tratado de incluir las es-
cies que más se aproximan a este ideal. También se hace mención
algunas especies que se citan muy a menudo por su valiosa made-
pero cuya silvicultura tropieza en la actualidad con demasiado
ficultades para recomendarlas como promisoras.

Laurel (América Central) pardillo, canalete (Venezuela, Colombia) cypre (Trinidad). Cordia alliodora.

Este árbol parece reunir el máximo de condiciones deseables. Inclusive se ha recomendado para sombra de cacao (3). La especie tiene una amplia distribución natural que va desde México hasta Bolivia, pero aparentemente hay numerosas razas ya que el desarrollo y la forma varían mucho, y aún los madereros reconocen diferentes calidades de maderas dentro de una misma región. En la vertiente del Atlántico de Costa Rica donde se ha observado esta especie con más detalle, el crecimiento es espectacular, llegando a más de 3 cm. de diámetro por año en los mejores ejemplares. Pérez (5) calculó que para esta región y en buenos suelos se podía llegar a la cosecha final en 25 años con una producción de 91,640 pies tablares por hectárea (o cerca de 520 m^3). Con un aprovechamiento intensivo esta producción puede aún mejorarse.

El árbol tiene una forma excepcionalmente buena y aún los ejemplares aislados tienen tronco recto y libre de ramas hasta considerable altura ya que hay una poda natural de las ramas inferiores. La copa es pequeña y el sistema radicular es aparentemente profundo. La resistencia al viento es excelente.

En la América Central el árbol no tiene enfermedades e insectos de importancia aunque en Trinidad hay un chancro de

serias proporciones. En algunos lugares de Costa Rica se ha observado una fuerte infestación de muérdago (Phoradendron robustissimum) contra el cual no se ha podido encontrar un control económico. Sin embargo, no se sabe a ciencia cierta cuál es el daño efectivo que causa este parásito.

La regeneración natural es muy abundante cuando hay muchos árboles semilleros. La especie compite ventajosamente con las especies invasoras del monte secundario que ocupan terrenos anteriormente cultivados y los grupos naturales más densos se encuentran precisamente en terrenos agrícolas abandonados. El cuido de tal regeneración puede redundar en la formación de rodales puros a muy poco costo como se demostró en terrenos del Instituto Interamericano de Ciencias Agrícolas (4). También pueden usarse satisfactoriamente varios métodos de regeneración natural que resultan relativamente económicos.

Finalmente, la especie no es muy exigente en cuanto a suelos aunque prefiere los profundos con buen drenaje. La madera es muy apreciada para construcción y ebanistería y rivaliza casi con el precio del cedro (Cedrela mexicana) en muchos lugares.

2. Pino, Pinus caribaea

Este pino cuya zona de distribución natural en zonas húmedas y bajas de Nicaragua y Honduras lo califica definitivamente dentro de la zona cacaotera, parece tener un magnífico porvenir. Las introducciones en años recientes en Trinidad y Guayana Británica han resultado muy prometedoras (6). Su crecimiento es rápido y diámetros anuales de más de 2 cm. son corrientes en los primeros años. La forma es excelente como cabe esperar de los pinos en general. Su tolerancia a suelos muy pobres en nutrientes lo hacen particularmente deseable para terrenos degradados. Hasta la fecha no se han reportado insectos o enfermedades de importancia. Entre las dificultades para su establecimiento, la mayor parece ser la escasez de semilla y la necesidad de inocular las raíces con micorriza, un hongo que facilita la asimilación de nutrientes y que se encuentra natural en los pinares nativos. Pero si pueden salvarse estos obstáculos, la especie está destinada a adquirir considerable importancia, especialmente en áreas de suelos pobres o degradados ya que la demanda para la madera de coníferas es excelente.

Eucalipto, Eucalyptus deglupta

En la América Central, el Eucalyptus deglupta, oriundo de la zona tropical del Pacífico al norte de Australia ha dado muy buenos resultados iniciales. El crecimiento es extraordinariamente rápido y la forma es excelente. En lugares donde se quieren obtener resultados rápidos, ésta parece ser la especie indicada. La madera es de calidad mediana. En su ambiente nativo en la isla de New Britain, goza de excelente demanda para construcción. Los raleos después de pocos años, de establecida la plantación, prometen postes de excelente forma. En Honduras, algunas plantaciones han tenido un crecimiento espectacular con 30.5 cms. de diámetro en 10 años (6).

Primavera, palo blanco, San Juan, Cybistax Donnell-Smithii

Esta especie se ve a menudo en cacaotales así como en cafetales de zonas bajas y húmedas del Sur de México y del Norte de la América Central. El árbol es de crecimiento rápido y ha alcanzado un promedio de 2 cm. de diámetro en los primeros 8 años. Sus flores de color amarillo oro son espectaculares. Desgraciadamente, su forma a menudo deja mucho que desear. Pero esto se debe a que generalmente se planta en terreno abierto y es posible que cierta sombra lateral puede inducir un crecimiento más recto. También parece que la especie es algo exigente en cuanto a suelos. La madera es muy apreciada para ebanistería, y para caras de madera terciada.

Teca, Tectona grandis

El principal defecto de esta especie de gran valor es que requiere buenos suelos, especialmente buen drenaje, y es necesario que se presente una estación seca bien marcada. Aún así existen algunas zonas cacaoteras donde la teca ha dado excelentes resultados, especialmente en aquellos lugares donde se emplea el riego para cacao. En Trinidad el Gobierno cultiva esta especie sobre suelos muy pobres pero de buen drenaje esperando llegar a la cosecha final en turnos de 60-80 años. Allí se aprovechan al máximo los raleos que se efectúan cada cinco años. En la América Central, cerca de Quepos en la Costa del Pacífico donde los suelos son excelentes, el crecimiento es mucho más espectacular y promedios de incrementos anuales de más de 2.5 cms. en los primeros 15 años son comunes. Allí se pueden calcular turnos finales de sólo 40 años.

6. Caoba (Swietenia macrophylla, Khaya spp.) y Cedro (Cedrela mexicana, Cedrela spp., Cedrela toona).

La perspectiva de establecer una plantación con especies tan valiosas como la caoba y el cedro es muy tentadora. Además de su valiosa madera, estas especies son de rápido crecimiento y en condiciones naturales de bosque, la forma generalmente es muy buena. Pero en la práctica los éxitos son pocos. Los principales defectos parecen ser los requisitos especiales de buen suelo y el ataque de un insecto taladrador del cogollo (Hypsipila grandella) el que aún cuando no mata el árbol lo deforma. Aún así, algunas plantaciones han obtenido un éxito notable como se reporta con la caoba en Martinica (2) y en Jamaica (6) y con el cedro en Ecuador. En Lancetilla al norte de Honduras, la United Fruit Co. ha establecido exitosamente algunas plantaciones de caoba (Swietenia macrophylla) y cedro (Cedrela mexicana) pero el crecimiento más extraordinario quizás se haya alcanzado con las caobas africanas Khaya spp. y el cedro de Asia, Cedrela toona, que en América parecen ser inmunes al temible taladrador. De todas maneras hasta tanto no se tenga más seguridades para obtener éxitos seguros, parece prematuro recomendar la caoba y el cedro de América para programas de reforestación en gran escala.

ESTABLECIMIENTO ECONOMICO DE PLANTACIONES

Una consideración previa de mucha importancia es la decisión que ha de tomarse sobre el tipo de regeneración, natural o artificial. Sólo en contados casos, la regeneración natural es adecuada en terrenos agrícolas que han sido recientemente abandonados y es posible trabajar con ella. En algunos lugares de Costa Rica esto ocurre en Cordia alliodora y muy esporádicamente con Cedrela mexicana. En este caso una buena práctica constituye en liberar los arbolitos valiosos que tratan de abrirse paso a través de la maleza. No es necesario limpiar todo el terreno sino que sólo es importante cortar los bejucos y aquellos árboles sin valor que entorpecen el desarrollo en altura. Cuando los bosques secundarios son más viejos, hay buenas probabilidades de encontrar una regeneración con muchos arbolitos de valor. En este caso la corta juiciosa de las especies sin valor y los bejucos, dejando los árboles que han de cosecharse en el futuro, es una práctica muy recomendable (4).

Cuando la regeneración natural no es suficiente hay que recurrir a la plantación. El procedimiento más común en este caso consiste en hacer semilleros y viveros y trasplantar las plantas en hoyos preparados de antemano en el terreno. Este método, aún cuando seguro, es relativamente caro y en los últimos años se han

alizado numerosas experiencias que permiten plantar con menos sto sin disminuir apreciablemente las posibilidades de éxito.

SIEMBRA DIRECTA

Es posible sembrar directamente en el terreno, especialmen- con semillas grandes. Pero aún con semillas pequeñas se han grado buenos resultados usando ciertas técnicas específicas. pitiendo experiencias realizadas en Africa, especialmente con calyptus, se ha ensayado con éxito en Turrialba la siembra di- cta del Cordia alliodora sobre "montoncitos incinerados" (1). potreros degradados donde tal sistema se ha aplicado con éxi- , se corta el pasto, en la época más seca, disponiéndolo en ntoncitos que luego se cubren en su parte superior con un poco tierra. Cuando el pasto es seco, se quema cada montoncito con que se mejora la textura y la fertilidad del suelo que estaba bre los montoncitos y sobre el cual se esparce la semilla des- és de fuertes lluvias. Aunque los costos iniciales son bajos es portante mantener una buena limpieza en los primeros años para itar la competencia pero para ello no es necesario limpiar to- el campo pero sólo las calles donde van alineados los monton- tos.

PLANTACION A RAIZ DESNUDA O EN ESCOBA

Para la mayoría de especies la plantación a raíz desnuda es cho más económica. Técnicamente es satisfactoria si se toman su- cientes precauciones en el trasplante. Es importante mantener s raíces bien abrigadas cuando se sacan del vivero. También es seable arrancar las hojas inferiores para evitar la transpira- ón excesiva y en caso de tener raíces muy largas, es preciso po- rlas. Para llevar los arbolitos que han de trasplantarse, las íces pueden impregnarse en un baño de barro y luego envolverse un trapo húmedo. Para la teca es bien conocido el trasplante de ocón" con tallo y raíz recortados, formando una pseudoestaca de os 10-15 centímetros. Este sistema también ha dado buenos resul- dos con Cordia.

MANTENIMIENTO DE LA PLANTACION

En cuanto al cuido y los cortes de limpieza de los arbolitos en los primeros años, sólo será necesario mantener una calle abierta dejando la vegetación natural ocupar los espacios entre calles. En esta forma no es necesario plantar muchos árboles, se rebajan los costos de la plantación, y se produce cierta sombra lateral que estimula el crecimiento vertical y sin muchas ramas. Se necesitarán menos limpias a medida que crecen los arbolitos ya que la mayor sombra elimina la competencia. En el curso de los años que siguen había necesidad de hacer raleos que producen postes y madera de construcción según las medidas que se obtienen.

COMBINACION CON AGRICULTURA

Finalmente, para reducir aún el costo de estas plantaciones, se ha comprobado que el sistema "taungya" que permite la utilización temporal del terreno para agricultura con la condición de que se cuiden los arbolitos plantados, puede ser aplicado con todo éxito en lugares donde hay presión sobre la tierra. El uso del suelo por solamente un año no representa mayor peligro para su degradación. Esto es una forma muy conveniente de transformar los terrenos forestales en plantaciones de valor y en algunos casos esto se efectúa en forma paulatina, aprovechando las modalidades de los agricultores locales u obreros de las plantaciones de cacao quienes están acostumbrados al sistema de agricultura nómada.

RESUMEN

En las zonas cacaoteras se encuentran a menudo terrenos que por su topografía o baja fertilidad podrán dedicarse al cultivo de especies forestales de valor. Se recomienda para este caso algunas especies que han dado buenos resultados como Cordia alliodora Pinus caribaea, Eucalyptus deglupta, Cybistax Donnell-Smithii y en algunos casos Tectona grandis. La caoba (Swietenia macrophylla) y el cedro Cedrela mexicana son especies controversiales.

Se describen varias técnicas satisfactorias tales como la siembra directa, a raíz desnuda o de tocón, el uso de calles en el monte y la combinación con agricultura que permiten reducir los costos de establecimiento de una plantación.

SUMMARY

In regions where cacao is cultivated, reforestation of timber ecies is often indicated for areas of steep topography or low rtility. Recommendations are made to establish suitable species, ch as Cordia alliodora, Pinus caribaea, Eucalyptus deglupta, pistax Donnell-Smithii, and in some cases Tectona grandis. Mahog- y (Swietenia macrophylla) and Spanish Cedar (Cedrela mexicana) e controversial species.

Different techniques which lower the costs, such as direct eding, use of bare-rooted stock and stumps, tending of planta- ons and possibilities of combination with local agriculture, are scribed.

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EL CACAO EN COLOMBIA

A. J. Monsalve*

Con respecto al cacao del país nos interesan dos tópicos especiales: a) el estado actual de los cultivos y b) la campaña de mejoramiento.

Estado actual

Casi todas las plantaciones del país se hallan en estado de decadencia siendo más notoria en los Departamentos del Cauca y del Valle. Cuáles son las causas? En primer lugar hay que tener en cuenta que planta tan delicada como ésta ha tenido un manejo pésimo. No parece sino que sus cultivadores - como hace años lo dijimos - hubieran puesto todo su empeño en perjudicarla. Sistemáticamente en todas partes se la ha manejado en las peores condiciones tanto en lo referente al suelo como en la selección de las variedades; en las prácticas sanitárias como en el manejo del agua; en la escogencia del sombrío como en la de las plantas asociadas. Por otra parte la edad de la mayor parte de las plantaciones, el desarrollo de enfermedades de carácter muy destructivo, el deterioro del suelo y la declinación del sombrío contribuyen poderosamente no ya a su estacionamiento sino a su rápida destrucción. Por último ha contribuído a agravar este estado de cosas un fenómeno meteorológico de incalculables proporciones cual es la disminución creciente de la precipitación pluvial, causada posiblemente por los desmontes incontrolados efectuados en las laderas de las cordilleras que delimitan la zona productora de los aluviones del Cauca. Como consecuencia paralela el lecho de los ríos se ha levantado al llenarse de material sedimentario arrastrado por las aguas que descienden de la región desmontada. Los efectos son tres de difícil modificación: escasa precipitación, generalmente mal distribuída, con detrimento de la humedad óptima, nivel freático muy cercano a la zona de raíces e inundaciones frecuentes. Por estos motivos las plantas sufren deterioro con merma de su producción y aun mueren. Para modificar esta situación es necesario repoblar el bosque, irrigar y regularizar el caudal de los ríos y posiblemente abandonar para este cultivo algunas regiones demasiado afectadas por corrientes subterráneas.

Deficiencias culturales

Son comunes a todas las regiones y comprenden aquellos aspectos concernientes al mal manejo del cultivo. Ellos consisten en esa

* Jefe de la Campaña de Cacao, Ministerio de Agricultura, Bogotá, Colombia.

raña asociación de café y de cacao y aun de otras plantas de me-
valor a veces mancumunada con un denso sombrío que forma un do-
impenetrable para la luz. Sombrío consistente en una mezcla
erogénea de plantas, algunas extremadamente perjudiciales. La
a que es un medio de regenerar las plantas para aumentar su pro-
ción, corregir su forma y mantenerlas sanas es una práctica es-
ádica que se realiza sin ningún juicio y que por lo mismo resul-
no pocas veces, contraproducente. La aplicación de fertilizan-
y correctivos es totalmente desconocida. No es, pues, de extra-
que las cosechas declinen cada vez más y que las plantaciones
aigan constantemente. Cultivos como éste, que extraen nutrientes
ante largos años sin restituírselos al suelo y que no reciben el
eficio de la remoción de la tierra como los anuales, por medio de
araduras, están sujetos a decadencia prematura y a bajas vertica-
de su producción.

ermedades y plagas

Las enfermedades y plagas, que tienen íntima relación con las
iciencias culturales, producen un grave impacto en el cultivo,
se refleja en escasa producción y en mortalidad elevada, a tal
to que no es aventurado predecir un colapso del cultivo, que a
ar del establecimiento de nuevas plantaciones tiene una produc-
n estacionaria desde hace varios años, al paso que las necesida-
del consumo se acrecientan continuamente. Hay enfermedades y
gas que atacan los frutos ocasionando hasta un 80% de pérdidas
un más, otras que atacan el tallo y las ramas producen gran
trozo y su daño avanza incontenible, pese a la muralla sanitaria
se le opone. Otras que atacan la raíz, de carácter muy destruc-
o aunque de lento avance, afortunadamente están confinadas a
as limitadas, pero que no por eso se pueden subestimar.

El pésimo estado de las plantaciones por mal cultivo hace que
incidencia de enfermedades y plagas afecte a una gran parte de
población cacaotera y que los estragos adquieran un alcance tre-
do. En general puede asegurarse que el estallido de ellas se de-
a malos métodos culturales, que hacen que la planta sea extrema-
ente receptiva.

En resumen la población cacaotera se halla en muy deficientes
diciones culturales; muy vieja; a veces, mal localizada; atroz-
te atacada por gran número de enfermedades y plagas y en suelos
deteriorados. Su producción por estos motivos es muy baja y
ntras subsistan será imposible aumentarla aun con la contribución
las nuevas plantaciones de origen clonal.

Mejoramiento de los cultivos

En tres frentes hay que operar para llegar a conseguirlo, a saber:

a) irrigación y drenaje;

b) educación del campesino; y

c) represión de plagas y enfermedades.

El primero es de orden estatal por su magnitud y sus desarrollos. Los otros son de ejecución conjunta entre agricultores y Estado con mayor participación de aquéllos. Estos dos puntos tendrán cumplido desarrollo por medio de un servicio de extensión especializado, vale decir, encaminado exclusivamente al cultivador de cacao.

Las regiones seleccionadas para estas operaciones deben someterse a un estudio concienzudo de todas sus condiciones, ya económicas, ya culturales, ya raciales, teniendo en cuenta que se necesitan agricultores que quieran mejorar, que tengan grandes problemas por resolver y que dispongan de medios económicos suficientes para ejecutar las obras planeadas. Poco valdría el interés del Estado por la educación de la masa campesina, si ésta no tiene medios para mejorar o carece de voluntad para hacerlo,o no tiene ambiciones porque carece de necesidades sentidas.

La educación campesina no tiene necesariamente que principiar por el mejoramiento de los cultivos en todos sus aspectos, porque puede que esa no sea una aspiración inmediata o una necesidad primordial del campesino. Es posible que, en muchos casos, sea más importante el mejoramiento del hogar y la enseñanza de prácticas menudas que levanten el nivel de vida familiar con el objeto de suscitar necesidades que obliguen a producir más para poderlas satisfacer. Casos habrá en que será mejor soslayar el objeto principal hasta tener una base firme que permita obtenerlo sin causar conmoción. El conocimiento cabal de la idiosincrasia campesina es el medio más seguro para llegar al fondo del problema. Es indispensable también prescindir de medios extraños al campesino, que no le sean familiares o que sean muy complicados. Siempre lo mejor es principiar por lo más elemental y que le sea más conocido a condición de que el resultado final sea aumento de su cosecha representado en dinero. Sin embargo no es el dinero sino su tranquilidad, de allí que, sin él saberlo descuide sus cultivos. Hay que crearle necesidades para que requiera dinero y así tenga el deber imperioso de mejorar sus cultivos para obtenerlo. Así se justifican el mejoramiento del hogar y la elevación del nivel de vida familiar.

Hay que tener mayor preocupación por la gente y un poco menos
r la finca al contrario de lo que suele suceder, a veces. Vale
s un saludo afectuoso que la más brillante demostración. Un pe-
eño favor hace más por la finca que el trabajo de muchos hombres,
rque en definitiva la labor con el campesino se basa en simpatías
no en ciencia; aquéllas labran el corazón y desbrozan el camino
ra que ésta pueda avanzar.

Hay que enseñarle al campesino prácticas de salud y de nutri-
ón. Muchas veces en sus dolencias reside el motivo para la des-
ención de su finca o para la falta de ambiciones.

Las demostraciones encaminadas a implantar prácticas mejoradas
a desarrollar habilidades serán cuidadosamente ejecutadas para que
constituyan siembra de errores y pierdan su finalidad. Se exigí-
siempre la presencia del dueño de la finca o de su inmediato in-
resado al efectuarlas, teniendo en cuenta que los obreros no tie-
n mucho interés en ellas.

Otra cosa muy importante es no darle nada al agricultor a tí-
lo gratuito, en cuanto sea posible. La ayuda material por medio
trabajadores, semillas, herramientas, etc., es una práctica vi-
osa que no educa, por el contrario fomenta hábitos perniciosos,
si siempre contraproducentes, como se ha confirmado en la reali-
d. El campesino lo que necesita es que se le den medios cultura-
s y facilidades para aprovechar lo que posee.

Una vez que el agricultor esté equipado con las herramientas
estas en sus manos por la extensión en las demostraciones, las
uniones, los trabajos en común, el mayor acercamiento social, las
formaciones, etc., el trabajo de campo en el incremento cacaotero
rá mucho más provechoso y de desarrollos más firmes y seguros.

Los siguientes problemas exigen inmediata solución: a) destruc-
n de cultivos intercalados, b) implantación sistemática de podas
cionales, c) control de plagas y enfermedades y d) rehabilitación
cultivos antiguos.

La primera medida que es la más importante en la tecnificación
cultivo es la de más difícil ejecución, porque choca de lleno
costumbres inveteradas tan antiguas como el cultivo, pero con
medios de que dispone la extensión es posible efectuarla y se
efectuado, de lo contrario el cultivo llegará en pocos años a su
na total. Pero donde el cacao está muy arruinado y los otros
tivos den buen rendimiento es aquél el que debe destruirse pre-
iblemente, si el cultivador no tiene posibilidades de ejecutar
renovación total o prefiere el cafetal que ya tiene establecido.
amos convencidos que esta medida hará duplicar la producción sin
entar el área de cultivo como ocurrió en el Huila en los cultivos
tratados por los años de 1940 y 1945.

Las podas son muy aceptadas por los campesinos y su generalización no presenta dificultades, pero hay que racionalizarla y sistematizarla. Podas que se efectúan cada 2 ó 3 años carecen de valor, porque la emisión de brotes anula su efecto al cabo de pocos meses perdiéndose así el objetivo buscado. La poda no debe limitarse al cacao solamente, hay que hacerla extensiva al sombrío si es muy denso. Cuando el sombrío es muy espeso la producción es escasa y las enfermedades y plagas se desarrollan progresivamente.

El combate de plagas y enfermedades por medios químicos y biológicos es un coadyuvante valioso, pero no más. Mientras no se desalojen las causas que las propiciaron su valor es muy limitado y en muchos casos es mejor no hacerlo. Pero si se han tomado las demás medidas tendrá efectos positivos y será muy bien recibido, porque el campesino cree ciegamente en los brevajes.

La rehabilitación de plantaciones viejas debe hacerse en forma total, arrasando toda la vegetación y destinando la tierra durante algún tiempo a cultivos anuales con el objeto de meteorizarla. En plantaciones grandes esta medida se puede desarrollar por etapas de conformidad con las posibilidades del agricultor. La renovación por medio de resiembras es ineficaz y desprestigia la obra. El método de resiembra tiene éxito en plantaciones nuevas o no demasiado viejas, sin cultivos intercalados ni demasiado sombrío, para reemplazar plantas lesionadas o muertas por Xyleborus o enfermedades accidentales.

SERVICIO QUE PRESTA LA CAMPAÑA NACIONAL DE CACAO

1. La Campaña Nacional de Cacao se opera como un servicio de extensión para trabajar con adultos con miras a la tecnificación del cultivo. Por consiguiente sus medios para llevar adelante este proceso educativo son las demostraciones, los días de campo, el cine, las circulares, los boletines, la radio, etc.

2. En las principales veredas de cada oficina seccional y de cada sector se establecerán fincas pilotos - una por vereda - donde se efectuarán, por medio de demostraciones, todos los trabajos que demanda la técnica del cultivo llevando rigurosa contabilidad de los gastos y de los ingresos. Para el efecto se tomará hasta una hectárea y a su lado como testigo se tomará otra parcela de la misma extensión, clase y calidad que no recibirá ningún tratamiento distinto del acostumbrado en la localidad a la cual también se le llevará rigurosa contabilidad. Al final de cada año se establecerán las comparaciones

de los resultados y se darán a conocer profusamente de todos los vecinos y de los demás agricultores de la oficina seccional. Cada vez que se efectúa una labor especial se convocará a los vecinos para enseñarles las prácticas respectivas.

De cada finca piloto se levantará un croquis con todos los detalles importantes, localizando linderos, caminos, acequias, cultivos diversos, topografía, clases de suelos, etc., además se harán resaltar los aspectos socio-económicos que tengan influencia en la comunidad.

En algunas fincas de la vereda se llevarán a cabo demostraciones de aquellas prácticas tendientes a solucionar los problemas propios de la región, previa convocación de todos los vecinos.

Las demostraciones versarán no sólo en aquellas prácticas propias del cultivo, sino en los demás ramos del negocio agropecuario, que contribuyan al aumento de los ingresos de las gentes y al fomento de una vida más holgada y segura.

En muchos casos los cultivadores de cacao tienen vacas, cerdos y aves o algunos de estos animales. Es deber de los funcionarios de la Campaña enseñarles prácticas de manejo y de alimentación. También deben enseñarseles el manejo de otros cultivos distintos al cacao.

Todo funcionario de la Campaña en cualesquiera posición que ocupe y lugar donde resida debe ser un agitador constante con el fin de promover cambios en la masa campesina. Hay que difundir frases positivas aquí y allá sin que con esto se quiera decir que se vuelva cansón por la continua repetición. Pero cada uno debe recordar que hay que inyectarle dinamismo a una comunidad que naufraga en la más profunda inercia.

Preparación de personal competente por medio de las demostraciones en las fincas y de cursos de entrenamiento.

El personal de campo de la Campaña, en su mayor parte, se escogerá entre los hijos de los cultivadores y de sus mayordomos por períodos de 6 a 12 meses. En esta forma se trata de preparar personal capacitado en la ejecución de las prácticas más avanzadas del cultivo.

Como una contribución indispensable al incremento del cultivo y en general del bienestar de la familia campesina, la Campaña será un vocero constante ante los organismos crediticios y las demás instituciones que tengan que ver con la comunidad rural.

En este orden de cosas la Campaña colaborará estrechamente con la Caja de Crédito Agrario efectuando el estudio de suelos

y de los demás factores que intervienen en el cultivo, elaborando el presupuesto respectivo y el proyecto de inversión para cada nuevo cultivador interesado en la obtención de crédito, de conformidad con la modalidad establecida para este tipo de prestatario.

8. La Campaña tendrá como una de sus funciones básicas la producción y distribución de semillas mejoradas y de toda clase de material de propagación. Para el efecto establecerá centrales de multiplicación de semillas y de estacas enraizadas y procurará producir clones resistentes a las principales endemias que azotan la población cacaotera.

9. La Campaña se encargará del reconocimiento de suelos y de la ecología de aquellas zonas incultas que por diversas causas parecen aptas para cultivos óptimos de cacao y que aun no se han incorporado a la economía nacional.

10. Por último la Campaña se preocupará intensa y constantemente por resolver por sí misma o por medio de otra organización, todos aquellos problemas que requieran el concurso fundamental de la investigación.

RESUMEN

Se describe la situación actual del cultivo del cacao en Colombia y las deficiencias en prácticas culturales y en control de plagas y enfermedades. Se presenta una descripción de los servicios que presta la Compañia Nacional de Cacao y la forma como se planea mejorar el nivel de vida del cultivador de cacao.

SUMMARY

The present situation of the cacao growing industry in Colombia is described, mentioning the serious effects of pests and diseases and inefficient cultural methods. The program of the National Cacao Campaign and the plans for improving the standard of life of cacao producers are presented.

PROYECTO CACAO EN VENEZUELA

M. Rojas*

RESUMEN

Se describe los planes que se han formulado para el desarrollo
la industria del cacao mediante actividades de extensión en los
stritos de Acevedo y Caucagua, Venezuela. Se hace énfasis en la
plantación de huertas viejas y la expansión del area actualmente
jo cultivo; el uso de variedades resistentes a la Escoba de Bruja,
mo los clones Scavina; el uso de fertilizantes; el control de
lezas con herbicidas; las podas; y el control de enfermedades y
agas.

SUMMARY

The plans which have been formulated for the development of
e cacao industry by means of extension activities in the districts
Acevedo and Caucagua are described. Emphasis is placed on re-
anting old plantations and extending the area under cultivation;
e use of Scavina varieties resistant to Witches' Broom; the use
fertilisers; weed control with herbicides; pruning; and di-
ase and pest control.

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upervisor, Programa de Cacao, Dpto. de Café y Cacao, Ministerio
e Agricultura y Cría, Caracas, Venezuela.

FOMENTO DEL CULTIVO DEL CACAO EN GUATEMALA

Servando Rivera*

(Versión condensada)

INTRODUCCION

Debido a la importancia que tuvo el cacao en Guatemala como país productor en épocas pasadas y por contar en la actualidad con una pequeña área de cultivo poco productiva y en malas condiciones (mala regulación de sombra, cultivos mixtos, etc.), se ha trazado una línea tendiente a mejorar dicha área, de acuerdo con los programas de Investigación, Fomento y Extensión. Introduciendo en esta forma todas las técnicas del cultivo que son necesarias y que deben realizarse en las plantaciones ya existentes, con el único propósito de aumentar la producción y mejorar en todo sentido el cultivo del cacao.

OBJETIVOS

1. Tratar de mejorar plantaciones ya existentes
2. Interesar a los agricultores para hacer nuevas plantaciones.

El primer punto puede lograrse mediante visitas a las fincas, recomendaciones, planes de trabajo tendientes a rehabilitaciones de cacaotales viejos y el control de enfermedades. En el caso de rehabilitación siempre se tiene el cuidado de sugerir que el plan se lleve a cabo en secciones.

El segundo punto se puede realizar por medio de demostraciones, en ensayos regionales en lugares visibles cercanos a carreteras; práticas mejoradas en el cultivo y ayudando a los agricultores a obtener materiales de propagación de calidad superior para sus nuevas plantaciones.

INVESTIGACION

Originalmente "La Hulera" Cuyotenango y luego en la Estación Experimental de Hule y Cacao "Los Brillantes", Muluá Retalhuleu,

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*Departamento de Hule y Cacao, Instituto Agropecuario Nacional, Guatemala

nan realizado varios estudios concernientes a mejorar estos dos tivos; pero por ahora solamente se concretará a mencionar los bajos de investigación que se efectúan y que se continúan haci- en los Brillantes. Estación Experimental que pertenece al In- tuto Agropecuario Nacional del Ministerio de Agricultura, y que dedica especialmente a investigar y fomentar los cultivos de hu- y cacao para impulsar así un aspecto más de nuestra agricultura ional.

ción de Cacao

Se dedica exclusivamente a los trabajos de experimentación pro- do materiales locales a base de selección y materiales introduci- de México y Costa Rica; estos materiales después de haber sido pagados cuidadosamente y con buenas características, se han segui- propagando para contar mas adelante con material que sea usado en fomento del cultivo.

FOMENTO

El móvil principal que indujo a extender áreas de cultivo del ao, fué que Guatemala cuenta con zonas bien definidas (según Hol- Age) para aumentar la producción en un futuro no muy lejano.

El fomento del cultivo del cacao en Guatemala se inició a tra- de selecciones hechas en plantaciones particulares y tambien a- vechando materiales de otros paises, tales como México y Costa . Entre los materiales de Costa Rica se tienen UF-650, 667, etc. estos materiales se comenzo a fomentar el uso del plantas pro- adas vegetativamente.

Para iniciar la primera fase del fomento del cultivo, se hici- almácigos con semillas corrientes adquiridas en fincas parti- res, para que sirvieran como patrones, así como también la con- cción de un pequeno propagador para el enraizamiento de estacas capacidad de 7,000 plantas enraizadas anualmente. (Tipo propa- r Turrialba No 2). Dicho propagador se hizo para producir mate- es destinados a jardines clonales de la Estación. El mismo ano , se comenzó la construcción de un invernadero para colocar los agadores destinados a aumentar la cantidad de plantas a distri- entre los agricultores interesados en el cultivo.

La segunda fase sirvió para dar a conocer a los agricultores los diferentes sistemas modernos de propagación, indicándoles las grandes ventajas que se tienen con dichos sistemas de producir más en menos tiempo. Para este fin fue necesario obsequiar plantas a los agricultores que se consideró más entusiastas y después de haber realizado varias visitas, obteniendo en esta forma lotes demostrativos.

La tercera fase comprendió inspecciones a las fincas que están en la zona tropical húmeda que abarca la región suboccidental del país. Así mismo también algunos lugares que están en la zona tropical seca, en donde sí puede establecerse el cultivo del cacao, aprovechando las vegas de los ríos o usando riegos.

En el año de 1959, se establecieron nuevas siembras en 28 fincas, con un total de 33.070 plantas (10.510 estacas, y 22.560 injertos). Actualmente se cuenta con un propagador eficiente con capacidad para producir 40.000 estacas enraizadas anualmente. Así mismo se cuenta también con un almácigo con capacidad para producir 125,000 plantas obtenidas de semilla para ser injertadas en su debido tiempo; dicho almácigo está protegido con tela plástica llamada sarán, que proporciona el 45% de luz. La disposición de las plantas está hecha en tal forma que permite el riego y el fácil manejo a la hora de ser injertadas. Las plantas estan sembradas en bolsas plasticas de 12 pulgadas de largo por 9 de diámetro. Colocadas en dos hileras juntas y separadas por calles de 60 centímetros

EXTENSION

El servicio de extensión agrícola es uno de los mejores medios de que se vale el Agente de Fomento para transmitir y propagar las nuevas técnicas al agricultor por medio de contactos directos. Estos contactos directos se hacen con el objeto de estimularlos e inducirlos a un determinado trabajo que luego redundará en beneficio de sí mismos y de la comunidad a que pertenecen.

Para llevar a feliz término un programa completo de extensión, se ha recurrido a las siguientes normas:

a) Inspecciones generales

b) Inspecciones especiales

c) Cursillos regionales

d) Entrenamiento de personal de campo

e) Demostraciones de métodos y resultados sobre temas específicos

f) Días de campo

g) Publicaciones

h) Asuntos económicos

RESUMEN

Se describe la forma como se está tratando de fomentar el in-
mento de plantaciones de cacao en Guatemala. Se usan plantas clo-
les propagadas por estacas y por injertos de clones locales, meji-
nos y UF. Trabajan a través de los métodos de extensión.

SUMMARY

The way in which the cacao industry is being encouraged in Gua-
mala is described. Rooted cuttings and buddings of local, mexican
UF selections are being used.

EXTENSION WORK ON COCOA IN WESTERN NIGERIA

J.O. Akinwolemiwa*

Western Nigeria is one of the three regions which constitute the Federation of Nigeria. It has an area of about 45,000 square miles and a population of 6 millions. Its most valuable export crop is cocoa, an average annual output of about 118,000 tons of which is produced almost entirely by individual farmers on small holdings. Because the farmer has been quick to appreciate the advantages of a cash crop the cultivation of cocoa has spread very rapidly, particularly between the two world wars, largely as a result of the spontaneous efforts of farmers whose over-enthusiasm has led to the use of land of varying suitability as well as the indiscriminate use of planting material. During the last twenty years, the discovery of the Swollen Shoot disease as well as the prevalence of Black Pod disease and Capsid pests of cocoa have offered a serious threat to the continued existence of this crop in the country. Extension work on cocoa in the Region has therefore been planned, bearing the above factors in mind as well as other aspects of cocoa production starting from the choice of suitable soil for planting to the care required up to the stage at which the bean is ready for the market.

ESTABLISHMENT

In order to ensure maximum production from the improved planting material which is being made available to farmers at subsidised prices, facilities are provided for a thorough inspection of land ear-marked for planting cocoa so as to guide the farmer on its suitability. In places where land that is suitable for cocoa production lacks, through previous arable cultivation, adequate overhead shade, farmers are assisted to establish shade plants of bananas, Glyricidia or Terminalia spp. before cocoa seedlings are planted. For this purpose the Government maintains nurseries of suitable shade plants at convenient centres for free distribution.

In the past, farmers have planted cocoa haphazardly. This has tended to make such measures as disease control not only difficult but also more expensive. Farmers are therefore guided in lining out their new cocoa farms before planting.

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* Acting Principal Agricultural Officer, Western Nigeria

The variety of cocoa originally grown by farmers was the melonado. In an effort to increase yields per acre, Government hrough its Extension Services, has been distributing seedlings f high yielding and early maturing Amazon cocoa among farmers or the past six years. At agricultural shows as well as on overnment Amazon cocoa multiplication plots the superiority of hese to the local variety in rapid growth, size and number of ods, has been demonstrated and this has stimulated a big de- and from farmers who can now buy seedlings at subsidized prices rom Government nurseries usually situated close to the areas here they are required for planting. Over 6 million seedlings re now distributed annually. Most of these are "basket" seed- ings in which a ball of earth around the seedlings is preserved o facilitate establishment without damage to the rootlets. armers are encouraged and assisted to establish nurseries on heir own farms by supplying technical guidance and some nurse- ies equipment as well as improved seed in order to enable them o attain the standard on Government nurseries. Farmers are gra- ually taking advantage of this scheme and this season are ex- ected to produce some 3 million seedlings in several coopera- ive nurseries with seedlings numbering over 100,000 each.

At the nursery sites, correct planting technique is demons- rated to individual farmers when they collect seedlings, and upervision of actual planting in the field is undertaken when equired. In addition there are demonstration plots conspicuous- y sited along busy agricultural roads where seedlings are plan- ed under shade side by side with those not under shade. Demon- tration plots showing the comparison of the performance of bas- et seedlings and seeds planted at stake are also laid down at onvenient centres. By a combination of demonstration and advice he recommended establishment techniques are now being widely a- opted by farmers to their advantage.

TRAINING OF FARMERS

Perhaps the field of agricultural extension work in which rmers' confidence has been most rapidly but firmly established that of crop protection. During the early forties farmers were rrified by the sudden appearance and rapid spread of the black d disease of cocoa. After a brief period of experimentation, a thod of control using copper fungicides was worked out. It was und necessary to arrange short courses in villages to train rmers to use the correct technique of applying the fungicides

as failure to do this might result in an ineffective use and hence loss of confidence in a valuable protective measure. Training was in the vernacular and adequate practice was arranged during the courses. The spectacular success of the spraying campaign during the early years of its introduction by reducing losses due to this disease, which may in very bad years account for over 30 per cent of the entire crop, has brought about a steady demand by farmers for training.

Soon after bringing the black pod disease of cocoa under control, capsid pests began to do widespread damage. Field experiments again promptly provided the clue to economic measures of control and the training of farmers on a large scale was organized. In order to ensure uniformity of training, a special syllabus with scripts was issued to all instructors. Because of the saving in crops which the introduced crop protection measures have achieved, the Government has since last year felt justified to subsidize the chemicals and provide credit facilities for the equipment used for this purpose. This, as well as the efficacy of the methods acquired by farmers trained in the control of pests and diseases of cocoa has stimulated such a demand for training that the organisation of training courses for farmers is now an annual event. During the last training season as many as 122,699 farmers were successfully trained at 579 centres. Very often itinerant training gangs equipped with pumps and chemicals are used so that farmers may be trained as near their villages as possible.

A follow-up service is also provided. Names and addresses of farmers trained are kept by the Extension Assistant in each area and the latter assists the farmer in planning his cycle of spraying and in putting right minor disorders in the farmer's spraying equipment. He finds out why some farmers in spite of their training may not be spraying and how best to overcome such obstacles as lack of sufficient stocks of chemicals for crop protection.

IMPROVEMENT IN QUALITY

From the manufacturer's point of view cocoa quality is based on the inherent genetical constitution of the cocoa tree from which the beans are derived as well as proper fermentation, cleanliness, and freedom from mould and insect damage. The latter features are determined by the treatment which the cocoa receives in the hands of the farmer and it is mainly with these aspects of quality that the extension workers have been concerned in the effort to maintain the general standard of cocoa exported at a satisfactory level.

Before 1926 the reputation of Nigerian cocoa was low on the orld Market because of its low quality. Government had to act wiftly by introducing standard grades of quality to which pro- uce must conform and an inspection service to ensure the mainte- ance of the standards set.

The first approach to the problem of raising quality of cocoa as the establishment of collective fermentaries at suitable cen- res throughout the producing areas. Farmers were encouraged to ring in their wet unfermented beans which were weighed, bulked, ermented and dried in the approved manner. The beans were subse- uently sold and the proceeds returned to the producers in the roportion of dry weight to wet cocoa supplied. All cocoa pro- uced at these fermentaries was Grade I which fetched a much high- r price than other grades, and farmers were thereby led to appre- iate that the exercise of a little care and trouble would bring ncreased returns. This quickly aroused interest in the preparation f good quality cocoa and the fermentaries became important demon- tration centres to which farmers in the area around could come to e taught how to carry out the operations for themselves.

At the end of the last war, it became necessary to launch n intensive propaganda campaign to improve the quality of cocoa o as to reach as many as possible of the 300,000 individual co- oa producers. The basis of the campaign was the publication in imple terms of pamphlets translated into the vernacular which ex- lained the essential features of harvesting, fermenting, drying, nd storing of cocoa, together with a description of the various ypes of defective beans likely to be produced by faulty methods s well as measures to be adopted to avoid them. Special emphasis as made on the necessity of drying cocoa on raised platforms to void contamination from domestic animals. Several demonstration rying platforms were erected throughout the cocoa growing areas or farmers to copy.

The campaign was organised on a Provincial basis under the eneral direction of the Provincial Agricultural Officers. All vailable facilities for disseminating propaganda on the widest ossible scale were employed. These included tours by chiefs and illage heads, special meetings arranged by local authorities and armers' unions and the fullest use of the press and propaganda ns equipped with loudspeakers. Any parcels of contaminated or nferior cocoa brought for grading were traced back wherever poss- le to their point of origin in order that renewed propaganda ould be directed among the farmers and buyers in the areas con- rned. The success of the campaign may be judged from the follow- g table which shows that while in 1946/47 cocoa season under 15% the cocoa was in Grade I and as much as 63% was in Grade IV,

the percentage of cocoa in Grade I rose steeply to 80% in 1948/49 and during the last three years at least 98% of the crop has been in Grade I even in record years such as 1956/57 season when as much as 143,360 tons were graded. The response by farmers was so successful that by 1950 it was possible to abolish grades III and IV.

Progress in the improvement in quality of cocoa in Nigeria

Season	Total production in tons	Grade I	Grade II	Grade III	Grade IV
1946/47	110,894	15%	1%	21%	63%
1947/48	75,582	47%	25%	21%	7%
1948/49	107,348	80%	16%	3%	1%
1949/50	100,520	93%	7%	-	-
1950/51	111,230	97%	3%	-	-
1951/52	104,679	98.4%	1.6%	-	-
1952/53	107,124	98.7%	1.3%	-	-
1953/54	100,481	97%	3%	-	-
1954/55	79,923	92.7%	3.7%	3.6%	-
1955/56	116,011	97.7%	1.6%	0.7%	-
1956/57	143,360	98.67%	1.33%	-	-
1957/58	80,583	98.01%	1.99%	-	-
1958/59	135,481	98%	2%	-	-

It should however be noted that the establishment of four grades of cocoa with marked price differentials by the Nigerian Cocoa Marketing Board was a contributory factor to the success of the campaign as the extra monetary reward for produce of the highest grade provided considerable incentive to take adequate care.

One factor which has threatened to upset the maintenance of quality is the difficulty of getting adequate sunshine to dry the beans in some years due to frequent rainfall and high humidity.

This occurred in 1954/55 and accounted for the fall in the centage of first grade cocoa and the re-introduction of Grade cocoa in that year. Where these conditions prevail cheap but icient artificial driers devised by the Extension Services are ng introduced. In most cases technical guidance in their con- uction is provided and efforts are being made to evolve cheap- and more efficient driers to meet the varying needs of the in- idual and groups of farmers.

PROPAGANDA

Propaganda by means of posters, leaflets, pamphlets with ill- rations as well as cinema and loudspeaker vans have been found y effective as an extension work tool. Special films on Black disease control and Capsid pests have stimulated local interest assisted tremendously in the drive to recruit farmers for train- . By means of these, even educated non-farmers have become aware the dangers of the diseases and pests of cocoa and have helped drive home to their parent and relatives who are farmers the ue of the schemes being pushed. By the propaganda means enume- ed above, farmers are reminded about the correct time to start spraying of their farms against pests and diseases and where obtain chemicals.

Looking back over the years, some credit can justifiably be imed by extension workers for the progress made as a result of ir efforts to educate cocoa farmers, often under difficult con- ions. With the drive to abolish illiteracy in Western Nigeria er the Adult Education Scheme as well as through the Free Pri- y Education Scheme which will produce an ever increasing number educated young farmers, it can reasonably be hoped that many tacles which illiteracy among farmers has hitherto presented to ension work will gradually disappear and a new age will dawn n valuable information by the printed word or by radio will be e to reach an ever increasing number of farmers.

SUMMARY

The progress of extension work in cacao in Western Nigeria is discussed. The main points of the program are: the provision of improved planting material at subsidised prices for shade plants; demonstrations of correct planting and nursery techniques at Government stations and on individual farms; training in control methods against Black Pod and capsids; the establishment of collective fermentaries; grading of finished cacao; and the dissemination of propaganda.

RESUMEN

Se hace un relato del progreso del trabajo de extensión de cacao en Nigéria Occidental. Los puntos esenciales del programa son: el suministro de plantas mejoradas a precios subvencionados y el suministro gratuito de plantas de sombra; demostraciones de las técnicas correctas para hacer viveros y plantaciones en estaciones gubermentales y en plantaciones individuales; entrenamiento sobre métodos de control contra la Podredumbre Parda y los cápsidos; el establecimiento de cooperativas de fermentación; la clasificación del cacao como producto terminado y la divulgación de informacion.

SUMMARY OF DISCUSSION

. E. Quartey-Papafio (Ghana)

I would like to make a few remarks on the extension work we e doing in Ghana. This would cover both extension, education and rect services. As in Nigeria, pests and disease problems are ong the most important line of work.

ollen Shoot

We are continuing with the cutting out of infected trees and ying grants. Contact trees are also cut and farmers are given ants for replanting. The disease is under control.

psid control

Work started on finding an insecticide for the control of psid on young plants. Hand painting with DDT was started and s followed by the application of the insecticide with hand rayers. To date 47,000 of these hand sprayers have been sold farmers.

Between 1954 and 1956 mistblowing mature trees with Gammalin s undertaken. Mass spraying of farmers' farms with Gammalin was arted in 1956 by the Division of Agriculture and in 1959 this mass raying was taken over by the farmers with a subsidy on the price spraying machines and Gammalin. Sales up to the end of March 60 were in the region of the following:

Motorised Sprayers	27,000
Gammalin	400,000 gals.

e total number of acres sprayed by the Division of Agriculture and rmers may be estimated at 2 to 2½ million.

ack Pod

This accounts for loss of about 18% of the crop in Ghana but emical control has not been found to be economical. We advise rmers to harvest frequently, reduce shade and keep their farms ee of weeds.

Farmers are receiving training in the use and maintenance of raying machines.

Our propaganda includes line planting, detection of Swollen oot and where to report outbreaks, capsid control methods and the vantages of using good planting material.

We have established, since 1949, 902 acres of Amazon cocoa in lots on farmers' land and a further 760 acres on our cocoa stations. the end of March 1960 a total of almost 6 million seedlings and lmost 5 million pods have been issued to farmers. We hope in the ear future to issue clonal seed to farmers and are establishing eed gardens which it is the intention to build up to 600 or 700 res.

L'ACTION DES SERVICES AGRICOLES DE LA MARTINIQUE EN FAVEUR DE LA CULTURE CACAOYERE

V.M. Bulle*

Le centre des préoccupations agricoles de la Martinique est defini par la canne a sucre, la banane et l'ananas, et le cacao ne peut dans le contexte économique et social y occuper qu'une place secondaire.

Pourtant, la culture du cacaoyer n'est pas négligée dans un programme de diversification des productions qui est à la base de la politique agricole que nous préconisons aux petites et moyennes exploitations. Cette diversification - illustrée par la sagesse paysanne qui conseille de ne pas mettre tous ses oeufs dans le meme panier - contribuerait à assurer aux petits exploitants des ressources régulieres et substantielles et de les mettre dans une certaine mesure à l'abri des grandes fluctuations inhérentes aux lois de la concurrence commerciales qui jouent rarement pour toute la gamme des productions.

Ainsi que l'histoire martiniquaise le prouve, la culture du cacaoyer ne constitue pas une inovation. La recherche de parasites d'introduction récente assez virulents pour en rendre l'exploitation délicate à prouvé que pour l'instant tout au moins, nous avions bénéficié d'une heureuse fortune.

La situation phytosanitaire est tres favorable et les maladies ou insectes connus ne causent que des dégâts mineurs.

Signalons en premier lieu la pourriture brune des cabosses due a Phytophthora palmivora qui est parfois assez intense pour justifier des traitements. Notons par ailleurs, puisqu'il à causé dans le passé de graves dégâts un pourridié des racines.

Parmi les insectes consignons les attaques de thrips (Selenothrips) qui piquent les extrémités non aoutées des rameaux, quelques "borers", de rares cochenilles et les dégâts sur jeunes feuilles causés par un petit hanneton (Leucothyreus nollete).

Une mention spéciale doit être faite des rats qui dévorent les cabosses mûrissantes.

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* Directeur des Services Agricoles, Martinique.

Pour l'instant, toutes les recherches de la présence du alai de sorcière" dû à Marasmius pernisiosus pourtant répandu ns les Caraïbes et l'Amérique du Sud sont restées vaines.

Les vestiges des anciennes plantations constitués par de tres eux arbres souvent retournés à l'état de nature sont extrêmement ins et produisent en dépit de l'absence de soins d'assez belles bosses renfermant de très belles fèves, assez grosses.

Ces vieux arbres provenant de semis sont en général des hy- ides aux formes tres variées (Trinitarios) avec prédominance des pes Criollo ou Forastero. Les véritables Criollos sont en fait ès rares et ont dû être éliminés par les producteurs au cours s temps passés en raison de leur faible productivité.

Trois types se rencontrent assez fréquemment:

Type A: Le plus fréquent à fruit arrondi vert, jaune orangé à maturité, a sillons peu prononcés, la base du fruit est arrondie marquée d'un tres léger étranglement près du pédoncule.

Type B: Qui constituerait une variation du type A à fruit vert, jaune clair à maturité, nettement plus allongé, a sillons peu prononcés et étranglement pédonculaire assez apparent.

Type C: Malheureusement beaucoup plus rare serait un Trinitario assez comparable a ICS 95. Le fruit est rouge violacé, jaune orangé marbré de rouge à maturité. La cabosse est longue et légerement incurvée au point stylaire, a sillons prononcés, la base est pointue et arquée avec un étranglement assez marqué vers le pédoncule.

	Type A	Type B	Type C
ngueurs extrêmes de la cabosse en cms	13 a 16	16 a 20	20 a 24
ngueurs moyennes en cms	14,5	17,3	21,7
rgeurs extremes de la cabosse en cms	7 a 9	7 a 10	8 a 10
rgeurs moyennes en cms	7,7	8,4	9,2
ds extrêmes de la cabosse en grs	330 à 475	300 à 600	735 a 960
ds moyens en grs	372	439	777

	Type A	Type B	Type C
Nombres moyens de graines par cabosse	44	41	44
Poids moyens d'une graine fraiche en grs	2,38	2,25	3,34
Poids moyens d'une graine seche en grs	0,98	1,19	1,21

L'action des Services Agricoles aurait pu se baser sur un travail de sélection de ces plants afin de promouvoir leur multiplication par voie végétative. Mais cette sélection semble avoir été déja effectuée à Trinidad par le College Imperial d'Agriculture. Monsieur Pound n'a-t-il pas rassemblé dans sa collection des plants provenant de ses prospections dans la Caraïbe, dont probablement quelques-uns issus des Antilles françaises?

Très en retard sur nos voisins britanniques à qui revient l'honneur d'une réhabilitation de la culture du cacaoyer dans les petites Antilles notre objectif n'a donc pas été de reprendre des études déjà faites mais de chercher une adaptation des résultats acquis compte tenu des conditions climatologiques et agronomiques particulières a la Martinique. Nous profitons de l'occasion qui nous est donnée pour exprimer nos vifs remerciements à la Commission Caraïbe et en particulier au regretté Docteur Shephard au Cocoa Board de Trinidad, aux différents Services d'Agriculture ainsi qu'à l'Imperial College d'Agriculture de Trinidad.

Une collection de clônes de cacaoyer importés de St. Vincent (en raison des risques d'introduction du Witches' Broom en prenant les plants à Trinidad) à été constituée au Jardin Desclieux à Fort-de-France. Cette collection comprend les clônes suivants (1) (2)

ICS 1 (b), 8 (b), 16 (a)(b), 32 (a)(b), 39 (a)(b), 40 (a), 46 (a), 47 (b), 60 (a), 61 (b), 80 (b), 84 (a)(b), 89 (b), 95 (a)(b), 98 (a)(b), 100 (b)

DS 1 (a), 9 (a)

GS 18 (b), 19 (b), 29 (a), 36 (b), 46 (b), 53 (b), 65 (b), 67 (b)

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(1) Les introductions des différents clones obtenus grâce au Superintendant of Agriculture in St. Vincent, FWI, ont été effectuées en novembre 1955 (a) et juillet 1959 (b). Les clônes soulignés d'un trait sont ceux qui ayant été reçus en qualité suffisante sont actuellement multipliés communément à Fort-de-France.

(2) ICS (Imperial College Selection, Trinidad) - DS (Dominica Selection) - GS (Grenada Selection) - UF (United Fruit, Costa Rica).

F 667 (b)
CA 12 (b)
MC 67 (b)

En outre, un verger a été planté à Sainte-Marie en utilisant es plants introduits en 1955. Le verger représente un total de has environ à raison de 1100 à 1200 pieds par hectare.

A partir de 1958 plusieurs vergers de comportement groupant es clones introduits en 1955 ont été plantés en divers points u territoire martiniquais. Ils nous permettront d'apprécier la aleur des différents clônes et de choisir en vue de limiter la ultiplication par voie végétative aux plus intéressants. Leur ntrée en fructification est probable au cours de l'année pro- haine. Tous les plants végètent de façon satisfaisante.

Nous donnons ci-après* les caractéristiques biométriques des ructifications de quelques clônes susceptibles de renseigner sur eur aptitude d'adaptation en Martinique

A la collection constituée au Jardin Desclieux a été adjointe groupe de bâches, serres et ombrières qui représente une possi- ilité de production de 40.000 plants par an. Cette installation de ultiplication correspond trait pour trait à celles que nous avons visiter à Sainte-Lucie ou dans les autres îles anglaises. Toute- ois, dans les bacs de multiplication fermés nous avons jugé utile disposer une rampe centrale de diffuseurs d'eau en brouillard tels u'ils sont employés à Sainte-Lucie pour les bacs à ciel ouvert. La erre d'acclimatation est dotée d'un humidificateur du type Defensor ui produit un véritable brouillard constitué de gouttelettes très ines. Par ailleurs, l'empotage des boutures racinées est effectué ans des sacs d'alkatène noir perforés à la base pour assurer un bon rainage.

Malheureusement la production des plants bouturés est très in- érieure à nos besoins annuels. En effet, tous les plants produits ont retenus longtemps à l'avance et suffisent a peine a satisfaire ne demande pressante, bien qu'aucune publicité n'ait été effectuée.

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* Voir tableau annexé

	ICS 39	ICS 40	ICS 46	ICS 60	ICS 84	ICS 95
Longueurs extrêmes cabosses	19 à 25	19 à 26	18 à 25	20 à 26	20 à 22	17 à 23
Longueurs moyennes cabosses	21,8	22,2	21,4	22,3	21,2	19
Largeurs extrêmes cabosses	8 à 10	8 à 10	7 à 10	8 à 10	8 à 10	7 à 9
Largeurs moyennes cabosses	8,8	8,9	9,2	9,0	9,2	7,8
Poids extrêmes cabosses	485 à 965	535 à 950	500 à 1050	315 à 535	535 à 1000	415 à 865
Poids moyens cabosses	682	718	793	677	778	598
Nombre moyen de graines par cabosse	42	42	42	39	36	37
Nombre extrême de graines par cabosse	29 à 48	36 à 48	36 à 48	29 à 49	28 à 43	36 à 43
Poids moyen d'une graine fraîche	4,0	4,5	3,2	4,5	3,37	2,97
Poids moyen d'une graine sèche	2,00	2,10	2,20	1,90	1,80	1,30

Nos objectifs les plus normaux correspondent à la plantation
e 100 has par an, et ce, au moins pendant 10 ans.

Notre attention a été retenue par les travaux extrêmement in-
éressants effectués au College Impérial d'Agriculture de Trinidad
ar B. G. Montserin, L. L. de Verteuil et W. E. Freeman sur les
eedlings hybrides de cacao. Nous souhaiterons obtenir le maximum
e renseignements sur cette technique d'hybridation et les résul-
at obtenus - en particulier sur la valeur commerciale des fèves.
i, comme nous l'espérons cette méthode de multiplication peut être
ise en place en Martinique, elle constituerait un appoint impor-
ant à la multiplication des clônes par boutures insuffisantes a
a réalisation du programme fixé. Elle possède de plus l'avantage
'un prix de revient beaucoup plus bas que la multiplication par
oie végétative.

Le problème immédiat le plus important est certainement celui
osé par le financement de l'effort consenti en matière de produc-
ion des plants. En effet, rappelons que nous nous adressons au
etit exploitant dont la trésorerie est toujours assez limitée et
ui ne peut envisager d'investir des sommes importantes dans l'a-
hat des plants à leur prix de revient. Les plants sont donc cédés
un prix de principe égal environ au quart du prix de revient ré-
l. Tant que la production de plants de boutures a été réduite par
uite d'un approvisionnement en boutures limitees cet effort a pu
tre supporté intégralement par l'Etat. Un nouveau mode de finance-
ent a dû être recherché par une association entre l'Administration
t les producteurs éventuels de cacao groupés en coopératives. La
articipation de l'Etat tout d'abord prépondérante cédera au cours
es années prochaines cette place à la coopérative, celle-ci ali-
entant la difference entre le prix de principe et le prix de re-
ient des plants par le produit d'une taxe (environ 1 pour cent) sur
e prix moyen de vente du cacao exporté.

Bien entendu ce prix préférentiel ne pourra être réservé qu'aux
euls adhérents de la coopérative. Cette organisation aura pour ob-
ectif complémentaire la préparation groupée, le conditionnement et
a vente des cacaos à l'exportation sur la France métropolitaine.

Pour mettre en évidence l'intérêt que représent la culture du
acaoyer sur une exploitation familiale, l'étude du prix de revient
a kilo de cacao a été établie comme suit:

as considéré: Plantation homogène, réalisée sur des terres de con-
istance et de richesse moyennes, à pente assez forte (10 a 30%).

Tous les travaux culturaux, défrichement préparation du sol et de la plantation, épandages d'engrais et traitements antiparasitaires sont effectués manuellement. Les frais de main d'oeuvre figurent sur un compte à part car nous nous sommes basés sur une petite exploitation à caractère strictement familial. Des indications sont portées in fine basées sur les taux de salaires journaliers (charges sociales incluses) pratiqués actuellement pour la culture de la canne à sucre en Martinique.

L'occupation du sol par la cacaoyère a été fixée à 40 ans dont 37 ans de production. Il a été admis - puisqu'il s'agit d'une plantation réalisée en partant de plants de boutures dans les clones sélectionnés - une production moyenne de 960 kgs de fèves séchées par hectare (densité de 800 pieds/hectare). La production généralement faible observée sur des plants âgés de 2 ans a été considérée comme négligeable.

Il a été admis que les 10% des plants ont dû être remplacés par suite de perte à la reprise.

Il a été admis que le producteur ayant adhéré à la coopérative bénéficiait d'avantages nombreux: plants au prix de vente de principe actuellement pratiqué, installations collectives de fermentation et de séchage. La participation à la coopérative est effective depuis le début de la plantation, la cotisation étant égale à 1,7 pour cent du prix de vente moyen du cacao (300 francs par kilo) pour la production normale de l'exploitation soit 4.800 francs par an et par hectare.

Les frais d'implantation de premiere année, amortissables en 40 ans ont été majorés d'un intérêt dégressif.

Il a été prévu un prêt à moyen terme de 200.000 francs remboursable en 5 ans et dont les intérêts ont été également répartis sur le même cycle.

Tous les frais ont été calculé pour une plantation d'un hectare.

lere année - Plantation

Le défrichement du terrain est suivi d'un piquetage et de la confection des canaux de drainage de 0,35 x 0,35 en courbe de niveau tous les 5 m. L'ombrage définitif constitué par des Immortelles, des Gliricidia est mis en place. De même pour l'ombrage provisoire de bananiers choisis dans les variétés consommables (banane créole, banane poyo, banane grande naine, etc.). Les trous de plantation des cacaoyers sont forés puis rebouchés après incorporation au sol de la fumure organique et minérale de base (10 kgs de fumier et 200 gms

'engrais 10.10.10 par pied). Autour de chaque trou sont disposés es plants de choux de chine (Collocasia antiquorum). Enfin la lantation des cacaoyers est effectuée.

Au cours de l'année un coutelassage sera réalisé, ainsi que 'épandage par deux fois d'une fumure minérale d'entretien a rai- on de 100 grs de sulfate d'ammoniaque par plant.

eme et 3eme année

Au début de la deuxieme année, un fourchetage sera pratiqué utour de chaque plant. Au cours de l'année, il sera continué par n coutelassage. Tous les trimestres un épandage d'engrais composé raison de 200 grammes de 10.10.10. En moyenne il sera effectué uatre traitements par an contre le thrips.

La vente à la récolte des choux de chine et des bananes bien u'apportant une rentrée d'argent frais substantiel (au minimum 85.000 francs), ne sera pas affectée aux recettes normales, mais omme un bénéfice exceptionnel.

eme année et suivantes

A partir de la quatrième année les frais d'entretien sont imités à la reconstitution périodique (tous les quatre ans) du éseau de canalisation, les anciens réseaux sont comblés de dé- ets végétaux divers (feuilles, branches, quelques herbes) et ebouchés. Les nouveaux canaux sont creusés en décalant d'une gne de plantation en remontant si possible. La fumure minérale ra augmentée pour atteindre en moyenne 800 grs d'engrais com- osé 10.10.10 par pied et par an répartis en 2 épandages.

A ces dépenses s'ajoutent des tailles des rejets et des bres d'ombrage le cas échéant ainsi que la récolte des ca- sses.

	Dépenses hors de l'exploitation	Nombre de journées de travail
1ère année		
Défrichement		20
Confection des canaux		20
Plantation des arbres d'ombrage définitif		1
Achat des arbres d'ombrage	1.000	
Plantation des bananiers y compris trous de plantation		35
Achat des souches de bananiers	35.000	
Plantation des ombrages temporaires (choux de chine)		10
Achat de l'engrais	12.800	
Achat du fumier	24.000	
Achat des plants de cacaoyers 50 x 880	44.000	
Forage et rebouchage des trous de plantation, incorporation de la fumure et plantation des cacaoyers		30
Coutelassage autour des plants		5
2 épandages d'engrais		2
Cotisation coopérative	4.800	
	121.600	123
2ème année		
1 fourchetage autour des plants et épandages d'engrais		10
1 coutelassage autour des plants		5
Achat d'engrais	25.600	
4 traitements 1.500 x 4	6.000	
Cotisation coopérative	4.800	
	36.400	15
3ème année (détail identique)	36.400	15
4ème à 40ème année, par année:		
1 fourchetage autour des plants		10
Achat des engrais	25.600	
Epandage des engrais		6
6 traitements	9.000	
Entretien de la plantation		20
Réfection des canaux une année sur quatre		5
Récolte du cacao		20
Cotisation coopérative	4.800	
	39.400	61

t pour 37 années de production 39.400 x 37 = 1.457.800

ntérêt d'un prêt de 200.000 à moyen terme remboursable la 5ème année:

$$\frac{200.000 \times 6 \times 5}{100} = 5.000$$

mpôt foncier: 100.000 : 100 = 1.000

oit pour 40 ans: 40 x 6.000 = 240.000

épenses:

21.600 + 36.400 + 36.400 + 39.400 + 1.457.800 + 60.000 + 240.000 = .991.600 Fr.

ain d'oeuvre: 2410 journées de travail pour 960 kgs x 37 = 35.520 kgs e cacao.

rais investis par kilo de cacao: 56,06 Fr.

émunération de la main d'oeuvre calculée à la base de 250 Fr. le kilo frais de fermentation, emballage, tirage à part).

$$\frac{250 \times 35.520}{2.410} = 3.684 \text{ Fr.} \pm 3.600 \text{ Fr.}$$

i on prend pour base du salaire journalier (charges sociales comrises) la somme de 1.200 Fr., le prix de revient s'élève alors à:

Dépenses matériels:	1.991.600
Frais de main d'oeuvre 1.200 x 2.410:	2.892.000
Total	4.883.600

Prix de revient du kilo de cacao: 4.883.600 : 35.520 = 137 Fr.

En conclusion, tout parait assez favorable à la poursuite et me à l'intensification de l'effort entrepris par la Direction des rvices Agricoles en faveur de la culture du cacaoyer. Si les proèmes d'ordre technique restent plus que jamais à l'ordre du jour, tre action mérite de s'orienter plus particulierement sur la vulrisation. La culture du cacaoyer doit intéresser principalement s petits exploitants agricoles et l'appui de la profession groupée coopérative doit savoir se faire de plus en plus pressant pour poser une présentation impeccable du cacao et assurer aux tonnages oduits toujours réduits une excellente réputation.

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31 mars 1960, la concordance de valeur monétaire est:

1 dollar U.S.A. :	494 Fr.	ou	4.94 NF
1 dollar F.W.I. :	287 Fr.	ou	2.87 NF
1 livre sterling:	1.382 Fr.	ou	13.82 NF

RESUME

On essaye de stimuler une diversification des productions agricoles surtout pour les petites et moyennes exploitations. Les pestes et maladies les plus importantes sont Phytophthora palmivora et thrips. Le "Balai de Sorcière" n'existe pas en Martinique.

Le cacao en Martinique est du type Trinitario, que l'on peut diviser en trois types selon les caractéristiques des cabosses et des graines.

En vue des travaux de selection effectués dans les Antilles britanniques, il a été décidé d'importer les meilleures sélections. La collection maintenant disponible comprend les sélections suivantes: ICS, DS, GS, UF, SCA et IMC, mais jusqu'ici seulment ICS 39, 40, 46, 60, 84 et 95 ont été distribuées.

Il est envisagé de planter 100 ha par an et on espère continuer ce plan jusqu'à un total de 1500 à 2000 ha.

Le prix de revient du kilo de cacao a été établi pour mettre en évidence l'intérêt que représente la culture du cacao sur une exploitation familiale.

SUMMARY

Attempts are being made to diversify crops, especially for small farms, and cacao is one of the recommended crops. Important pests and diseases are Phytophthora palmivora and thrips. Witches' Broom does not exist in Martinique.

The cacao in Martinique is a Trinitario type, which can be divided into three types of pod and seed characters.

In view of the selection work done in the British West Indies, it was decided to import the best selections. Clones now available include ICS, DS, GS, UF, SCA and IMC selections; but the only ones so far distributed are ICS 39, 40, 46, 60, 84 and 95.

It is intended to plant 100 hectares a year until 1500 - 2000 hectares are planted.

Figures on the cost of production of cacao are given, showing that it is an attractive crop for the small farmer.

RESUMEN

Se trata de estimular una diversificación de cultivos agrí-
as especialmente en las pequeñas plantaciones y uno de los cul-
os recomendados es el cacao.

La Escoba de Bruja no existe en Martinica. Los pestes y enfer-
ades importantes son Phytophthora palmivora y "thrips". El ca-
de Martinica es de tipo Trinitario que según las caracterísiti-
de las mazorcas y semillas puede dividirse en tres grupos.

En vista de los trabajos de selección efectuados en las Antillas
tánicas se ha decidido introducir las mejores selecciones disponi-
s.

En los jardines Desclieux, Fort de France, se dispone de clones
, DS, GS, UF, SCA y IMC, pero se distribuyen unicamente ICS 39,
46, 60, 84 y 95.

Está proyectado sembrar 100 hectares por año hasta llegar a un
al de 1500 a 2000 hectares.

Se hizo un cálculo de costo por kilo de cacao el cual muestra
el cacao es un cultivo atractivo para el pequeño agricultor.

PERSPECTIVES D'UNE RELANCE DE LA CACAOCULTURE EN GUADELOUPE

Albert Aurand [1]

Sans revenir sur les conditions écologiques (climat et sol) de la Guadeloupe qui sont connues pour être favorables, mentionnons que le cacaoyer a fait l'objet, au début du siècle d'une importante culture puisque les exportations à cette époque atteignaient environ 1.000 tonnes par an.

Depuis le cyclone de 1928 qui a ravagé la majorité des cacaoyères, nous assistons jusqu'en 1956 à un désintéressement général des planteurs. A cette date et en prévision des dangers de la monoculture, un comité de propagande créee sous l'égide de la Direction des Services Agricoles, a tenté d'entreprendre la relance de cette culture. Sous l'influence de nombreux facteurs défavorables les résultats escomptés n'ont pu être réalisés.

Examinons successivement la répartition géographique de l'aire des culture, le matériel végétal amélioré dont nous disposons, les recherches effectuées par l'I.F.A.C. et les problèmes de multiplication rapide que souhaite la Direction des Services Agricoles qui est maintenant pourvu d'un Ingénieur Vulgarisateur chargé des cultures "Café, Cacao".

REPARTITION GEOGRAPHIQUE DE LA CULTURE

Vers 300 m, sur la côte du vent de l'île volcanique, dans les "hauteurs" des villes littorales, l'agriculture se diversifie et la grande culture bananière et sucrière associée à la savane d'élevage est relayée par les plantations arbustives où dominent caféiers et cacaoyers.

Ce sont en Guadeloupe les hauteurs de:

Trois Rivieres, Gourbeyre, Sainte Rose, Lamentin, Petit Bourg, Capesterre, Saint Claude, Deshaies, Pointe Noire.

En Grande Terre ce sont:

Lesgrands Fonds de Sainte Anne, Gosier, Grands Fonds du Moule, Morne à l'Eau, Abymes.

La lisière des grands bois qui drapent la chaine volcanique est ourlée par cette longue bande de polyculture arbustive et vivrière qui part de Dizur-Desbonnes à Sainte Rose et qui, par Duportail, Prise d'Eau, les hauteurs de Lézarde, Carrère et Montébelle, Ilet

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[1] Chef de Services Agricoles, Guadeloupe.

rou, Routhier, Fonds Cacao, l'Habituée, rejoint les hauteurs de ois Rivières, de Gourbeyre et de Saint Claude. Là, dominent la renne et la petite propriété.

INVENTAIRE DES COLLECTIONS IMPORTEES CES DERNIERES ANNEES ET TRAVAUX DE SELECTIONS ENTREPRIS

Importation de boutures racinées

Dès 1955, la Direction des Services Agricoles en liaison avec l'Institut Français des Recherches Fruitières Outre Mer (I.F.A.C.) a entrepris une campagne en faveur de la "rehabilitation de la culture du cacao" en Guadeloupe.

Courant, Juillet 1956 et Mars 1957 des boutures ICS en provenance de Saint Vincent et de Sainte Lucie ont été introduites et plantées dans trois vergers de multiplication, respectivement situés:

a) Le premier à Neufchâteau, commune de Capesterre, sur la station de l'I.F.A.C.;

b) Le second chez M. Adrien Dormoy (Bois Debout), commune de Capesterre;

c) Le troisieme chez M. Guy Dormoy (Grande Maison), commune de Trois Rivières.

Depuis Mars 1958, un certain nombre de rameaux et de feuilles ont été prélevés sur ces plants. La multiplication se fait au fur et à mesure des possibilités.

A la fin de l'année 1958, un millier de boutures nouvelles avaient été mises en terre chez des petites planteurs et sur la Station de Neufchâteau.

Boutures introduites: ICS 1, 6, 8, 95, 98, 39, 40, 46, 60, 84. La multiplication, actuellement, ne se fait qu'à partir de ces clônes.

Importation de graines

Des graines prélevées sur des peuplements homogènes d'ICS à la Pastora (Trinidad) ont été introduites en 1955 sur la Station de Neufchâteau. Il s'agit là des ICS 95, 85, 45, 44, 25, 6, 1 et P. 18.

Les plants issus de ces fèves ont été plantés sur la Station de Neufchâteau. Quelques arbres commencent à produire. Comme prévu, ceux-ci ne sont pas homogènes quant à la forme, la couleur des cabosses.

Des études morphologiques sont entreprises sur ces cacaoyers au fur et à mesure des récoltes. C'est a partir de ce matériel qu'il sera possible par la suite d'obtenir une premiere série d'hybrides.

D'autre part, l'Imperial College of Trinidad a fourni un certain nombre de fèves qui ont été distribuées à des planteurs de l'Île (1957 et 1958). Les livraisons de plants ont été faites en pots de bambou.

Trinidad a également livré des fèves provenant d'hybrides Paraguay, Trinidad.

L'I.F.A.C. a également procédé à une sélection en Guadeloupe sur les rares cacaoyers encore vigoureux et productifs. Les fèves récoltées ont été semées à Neufchâteau en vue de constituer une collection qui permettra l'étude de ces clônes.

A ce jour, seuls les arbres de la Station de Neufchâteau font l'objet d'observations.

Le matériel le plus intéressant, hormis les clônes ICS, sont les seedlings 1955 actuellement en production, en particulier les P. 18.

Il est donc possible que, parmi les "hybrides" introduits en 1955 (il faut considérer comme tels les seedlings de la Pastora) l'I.F.A.C. trouve des types particulièrement intéressants quant à la vigueur et à la productivité. Lorsqu'il aura détecté, puis contrôlé des sujets intéressants, leur multiplication sera faite en vue de leur plantation en verger-pilote et, si les caractères reconnus se confirment, pour diffusion à l'extérieur.

REHABILITATION DE LA CULTURE CACAOYERE EN GUADELOUPE

Une première tentative a été faite en 1956 par la création d'un Comité de Propagande avec pour objectif la plantation de 300 hectares par an à compter de 1957. Cet objectif ambitieux n'a pas pu être atteint pour les raisons suivantes:

- Inorganisation collective du conditionnement et de la commercialisation;
- Attrait supérieur de la banane jusqu'en fin 1958;
- Délai de production jugé trop long (aux Antilles, l'argent doit être gagné rapidement).

Les surfaces effectivement plantées au cours des années 1957 1959 peuvent être estimées a une dizaine d'hectares.

Depuis l'éffondrement des cours de la banane en Septembre 1958, ne évolution très sensible de l'état d'esprit chez les agriculteurs est fait jour et se confirme depuis. Pour l'année 1959, c'est 10 15 hectares qui pourraient être plantés et cette superficie pourit atteindre 50 hectares et plus dans les année futures.

Pour la réalisation de ce plan de développement de la culture cacoyère en Guadeloupe, il est indispensable que la production boutures racinées soit intensifiée après extension des champs "pieds mères". D'autre part, une aide technique soutenue doit re prodiguée aux planteurs a tous les stades, non seulement de culture mais également sur le plan technologique. Ce programme it aboutir à la formation de coopératives de conditionnement et vente des produits récoltés.

RESUME

Au début du siècle, Guadeloupe exportait environ 1,000 tons de cacao par an, mais depuis un cyclone en 1928, on a noté désintéressement général des planteurs.

Ce n'est qu'en 1956 que l'intérêt pour cette culture c'est nouvelé. On a effectué l'importation de boutures racinées et mence de clones ICS de 1955 à 1958.

L'IFAC a également commencé à faire des selections locales.

Une première tentative de rehabilitation de la culture, ensagée à 300 hectares par an, a echoué, el seulement une dizaine hectares ont été plantées de 1957 à 1959.

RESUMEN

A principios del siglo, Guadalupe exportaba aproximadamente 1,000 toneladas de cacao al año, pero después de un ciclón en 1928 se registró una pérdida de interés de parte de los agricultores. No fué sino hasta en 1956 que este interés volvió a nacer.

Se efectuaron importaciones de estacas enraízadas y de semillas de clones ICS entre 1955 y 1958.

IFAC también comenzó un programa propio de selección local.

Un primer ensayo de rehabilitación de 300 ha/año falló y solamente 12 hectáreas fueron sembradas entre 1957 y 1959.

SUMMARY

At the beginning of the century, Guadeloupe exported about 1,000 tons of cacao a year, but after a hurricane in 1928, the farmers lost interest in the crop, and interest was not renewed until 1956.

Rooted cuttings and seeds of ICS clones were introduced between 1955 and 1958, and IFAC began its own local selection program.

An early attempt at rehabilitation involving 300 hectares per year failed; only 12 hectares were planted between 1957 and 1959.

NOTE SUR LA CACAO-CULTURE EN GUYANE FRANCAISE

M. Canoz*

La culture du cacao est assez ancienne en Guyane Française, dès 1825 l'on comptait environ 500 hectares de cacaoyères. Ces ntations étaient établies par moitié sur terrains dioritiques l'Ile de Cayenne - Comté, Roura - et par moitié sur argiles s la région de l'Approuague. Actuellement, la plupart de ces ntations sont abandonnées, mais il existe encore quelques ts partiellement exploités. Les arbres existant sur ces annes plantations présentent, en général, un bon aspect et paissent exempts de maladies ou de parasites dangereux.

Coste explique cette situation par "des conditions édaphiques s favorables, qu'il s'agisse de sols argileux recouverts de pésse° sur une épaisseur de 10 à 50 cms extrêmement fertiles de mbouchure de l'Approuague, ou des sols dioritiques des environs Cayenne".

Le climat de la Guyane est également favorable à la culture cacao.

Jusqu'à ces dernières années, malgré une production relativeit importante des arbres abandonnés, et une belle qualité des es, la récolte a été souvent négligée. C'est à partir de Janr 1955, sous l'impulsion de l'Ingénieur en Chef Thomassin, et a demande du Conseil Général de la Guyane qu'a été entreprise relance de la cacao-culture sur des bases rationnelles:

Au Jardin d'Essais de Cayenne fut effectué un petit peuplement provenant de fèves d'ICS 1 et de sélections prélevées à Roura et Pariacabo.

Deux agents du Services de l'Agriculture furent envoyés en stage de spécialisation à Trinidad.

Plus tard, sur les conseils de l'I.F.A.C., une cacaoyère expérimentale fut installée à la Station de Suzini, près de Cayenne, à base de clônes fournis par la station de l'I.F.A.C. à Neufchâteau, Capesterre, (Guadeloupe); il s'agit des clônes ICS 95, 8, 60, 6, 98, 39, 1, 40, 46.

La SATEC+(ex Creditag) vient de produire 8.000 plants de seedlings destinés aux agriculteurs de la SICA de Macouria.

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* Directeur des Services Agricoles, Guyane Français.

+ Société d'Assistance Technique et de Credit.

° On donne le nom de "pégasse" aux accumulations de matières tourbeuses, plus ou moins décomposées.

5. Un crédit de 7 millions de francs vient d'être attribué à la Guyane par le FIDOM, qui permettra d'installer, sur les pentes de Roura, un centre de multiplication de 10.000 plants provenant de boutures et 50.000 plants provenant de semis, par an. A cette effet, un second envoi de clônes est attendu de la Martinique, dont 5 ICS et le GS 29.

6. Dès cette année, les distributions suivantes seront faites dans l'Ile de Cayenne et aux environs de Macouria, par la Direction des Services Agricoles (D.S.A.). 1.500 sujets provenant de semis, 400 provenant de bouturages.

Des contrats sont établis entre la D.S.A. et les agriculteurs volontaires pour la constitution de cacaoyères, aux termes desquels les Services Agricoles mettent en place les plants, et les bénéficiaires s'engagent à les entretenir suivant les conseils qui leur sont donnés par les spécialistes du cacao. Les agriculteurs qui ont bénéficié de plantation de clônes s'engagent à autoriser le prélèvement de nouvelles boutures, suivant les normes, au fur et à mesure des besoins de la vulgarisation. La production est entièrement réservée aux agriculteurs, et l'organisation commerciale de la collecte est prévue par la SATEC, afin de permettre le lancement de l'opération sur le plan du commerce général du Département.

Nous signalerons, pour finir, que le prix de revient de production du plant de semis est d'environ 50 Fr., alors que le prix du plant de boutures est d'environ 200 Fr.

RESUME

Bienque les conditions climatiques et le sol en Guyane Française soient favorables à la culture du cacao, laquelle a été abandonée pendant longtemps.

A partir de 1955, on a commencé la relance de la cacao culture avec l'aide des mesures comme la distribution des semences et clônes selectionés, la spécialisation de personnel local, et les travaux experimentaux.

RESUMEN

A pesar del hecho que las condiciones climáticas y el suelo de as Guyanas francesas se prestan para el cultivo del cacao, éste ha ido prácticamente abandonado durante muchos años.

Desde 1955 se trató de estimular la industria por medio de la istribución de semillas y clones mejorados, el entrenamiento de ersonal local y trabajos experimentales.

SUMMARY

Although climatic and soil conditions in French Guiana are uitable for cacao, the crop has been practically abandoned for a ong time.

Attempts to revitalize the industry have been made since 1955, such measures as distributing improved seed and clones, training local personnel and experimental work.

HISTOIRE DE LA CULTURE DU CACAOYER EN MARTINIQUE*

E. Goyeneche**

"Le cacao est aussi propre à l'Amérique que le café l'est à l'Arabie et le thé a la Chine", dit avec raison le P. Labat dont l'étude sur le cacao confirme une fois de plus cette universelle compétence et cette activité débordante qui font de lui la figure la plus attachante peut-être de l'histoire antillaise.

De fait les noms de "cacao" et de "chocolat" d'origine indienne, furent transmis aux Européens par les premiers colonisateurs espanols de l'Amérique. Le cacaoyer poussait à l'état naturel sur le continent américain depuis l'Amazone jusqu'au Yucatan, dans les Grandes Antilles à Cuba, Saint-Domingue et Puerto Rico, dans les Petites Antilles à la Grenade, la Dominique et surtout la Martinique.

Pendant longtemps semble-t-il, les colonisateurs de la Martinique ignorerent l'existence de ce précieux arbre dans leur île. Le cacao qui existait a Sainte-Croix en 1647 d'après Rochefort ne fut connu que dix ans plus tard selon Dutertre à la Martinique ou les Caraïbes en révélerent l'existence dans la Capesterre à Du Parquet. On découvrit plus tard de très vieux cacaoyers à l'état sauvage sur les terres de M. Merville a Sainte-Marie, des chasseurs de cochons marrons, dont l'un portait le nom pittoresque de Brindacier, assuraient au P. Labat en avoir souvent trouvé dans le centre de l'île. Quand le P. Dutertre écrivait, on en était encore à la période des essais. Mais le Pere affirmait déjà: "Si les habitants des Iles s'étudient à la cultiver, je crois qu'ils pourront faire un profit considérable".

Ce fut un juif portugais, Benjamin Dacosta, expulsé du Brésil probablement en 1654 et en relations d'affaires avec les Espagnols, les Hollandais et les Anglais, qui planta en 1660 la premiere cacaoyere sur le chemin de Saint-Pierre à Morne-Rouge, à une demi-lieue de l'habitation la Montagne au bas de ce que l'on appelait le Reduit de l'Ile. Malgré l'autorité de May, auteur de l'Histoire Economique de la Martinique, nous n'avons aucune raison de douter de ce fait enregistré par des contemporains, dont l'un, le P. Labat, a même connu l'héritier de Dacosta venu en Martinique recouvrer des créances du défunt. Dacosta ne profita en effet guère de son initiative, la Compagnie des Indes Occidentales ayant racheté la Martinique aux héritiers Du Parquet en 1664 et ayant expulsé les Juifs dont elle craignait la concurrence. Le principal bénéficiaire de l'affaire fut un certain Bruneau que ses fonctions de Juge Royal n'avaient pas empêché de s'associer à Dacosta et qui le dépouilla sans scrupule.

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* Extrait de l'ouvrage "Des hommes et des Isles", Fort-de-France - 1957-1959.

** Archiviste en Chef, Martinique.

Fait curieux: Ce furent également des Juifs portugais et spagnols expulsés de la Péninsule qui fondèrent à Bayonne le commerce du cacao, puis l'industrie du chocolat et nous verrons les relations de Bayonne avec la Martinique sous ce rapport.

Très vite, l'exemple de Dacosta fut suivi par les principaux planteurs de l'île; si le terrier de 1671 ignore encore l'existence des cacaoyères, si en 1684 encore, le cacao de la Guadeloupe était considéré comme une curiosité à Paris, des l'année suivante, l'intendant Begon pouvait écrire: "Je vous assure que l'on fait ici du très bon chocolat avec du pur cacao de la Martinique sans y joindre celui de la Nouvelle-Espagne et je vous dirai que j'ai mangé depuis huit jours du cacao confit qui est une tres bonne confiture. J'avais une habitation que j'ai vendue depuis huit jours sur laquelle il y a plus de dix mille pieds qui produisent un très grand revenu." Le même intendant ajoutait d'ailleurs la même année 1685: "La Martinique est la seule des îles qui fait commerce de cacao, il serait à souhaiter qu'on pût en avoir un débit assuré, les habitants se porteraient très volontiers à en planter." En 1694, le P. Labat arrivant à la Martinique, énumère plusieurs cacaoyères sur la route de Saint-Pierre au Macouba: Celle du Marquis de Maintenon d'Angenne sur l'habitation la Montagne, celle des religieux de la Charité au Morne-Rouge, celle de Courtois après le Morne de la Riviere Falaise, à Basse-Pointe la cacaoyère de Verrier, une autre près du Fonds Saint-Jacques, appartenant à un certain Raffin. Au Fond Saint-Jacques même, appartenant aux Dominicains,le P. Labat organisera une magnifique plantation de cacao, dans laquelle en 1697, il plantera les premiers pieds de vanille donnés par les Jésuites de Cayenne. Monsieur de Cailus, ingénieur général des Iles Françaises et Terre-Ferme d'Amérique, et auteur d'une Histoire Naturelle du cacao, était lui aussi propriétaire d'une cacaoyère dans le centre de l'île. Les habitations voisines du Fort-de-France eurent elles aussi des "cacodières" selon l'expression de l'intendant Robert en 1696. Enfin en 1704, parmi les titres qui firent annoblir Pierre Du Buc figure le fait qu'il fut l'un des premiers à avoir entrepris la culture du cacao à la Martinique.

Du goût des Martiniquais pour le chocolat, témoignent entre autres de Monel, conseiller honoraire au Conseil Souverain qui, en 1705, à l'âge de 83 ans, montait à cheval sans étriers et faisait de longues randonnées, se nourrissant presque exclusivement de chocolat et de biscuit, ou le Capucin, curé des Anses d'Arlets, qui ne faisait qu'un repas le soir et se contenait d'une tasse de chocolat dans la journée; tout le monde s'en émerveillait mais le P. Labat révèle que cette "tasse" contenait une chopine de madere, 4 onces de chocolat, 6 onces de sucre et 3 oeufs; il ajoute avec une malice toute confraternelle: "Je suis sûr que tout autre qu'un Capucin aurait pu demeurer vingt-quatre heures sans rien prendre après une pareille tasse de chocolat."

Mais seule l'exportation pouvait provoquer à la Martinique le développement de la culture du cacao. Or, le principal client, la France, boudait le cacao martiniquais. En réalité ce ne fut qu'après 1660, que le chocolat, lancé par Mari-Thérèse d'Espagne, devenue reine de France, fut à la mode à Paris. Mais les Français préféraient le cacao de la cote de Caraques, c'est-à-dire de la région de Caracas, réputé moins amer et moins sec, à celui des Iles. Naturellement le P. Labat, que je soupçonne de se faire l'agent de publicité des planteurs martiniquais, proteste contre ce préjugé et cite l'exemple du vice-amiral des Galions d'Espagne, le Marquis de la Rosa, époux d'une Martiniquaise, qui mélangeait à parts égales le cacao de Caraque et celui de la Martinique,mais l'intendant Robert lui-meme avouait à la même époque: "Je doute que le cacao de la Martinique soit trouvé aussi bon que celui de Caraque, paroissant beaucoup plus sec." En outre, la réglementation du commerce entravait la consommation du chocolat, surtout dans le peuple. Dès 1659, un certain David Chalion avait reçu le monopole de la vente du chocolat en France; ce privilège étant expiré en 1681, le commerce libre dura jusqu'en 1692, date à laquelle un édit établit une Ferme du café, du thé, du cacao et de la vanille, François Damane eut le privilège de la vente, mais le chocolat fut taxé à des prix prohibitifs: la "prise" de chocolat valait 8 sols tandisque la même quantité de thé ou de café valait 3 sols 6 deniers. Un arrêt du Conseil de 1693 révoqua ce privilège et fixa les droits d'entrée du cacao a 15 sols la livre, du chocolat à 20 sols et de la vanille à 60 sols. L'exportation du cacao était autorisée et des entrepôts créés à Dunkerque, Dieppe, Rouen, Saint-Malo, Nantes, La Rochelle, Bordeaux et Bayonne. L'erreur subsistait d'ailleurs d'appliquer le même droit prohibitif au cacao des Iles Françaises qu'à celui de Caraque. Bayonne devint vite par sa situation le principal entrepôt du cacao: Les Espagnols, grands amateurs de chocolat, en avaient cependant laissé le commerce aux Hollandais qui le transportaient des colonies espagnoles à Cadix et sur les côtes de Biscaye, Bayonne constituait pour eux un relais commode, d'où le chocolat gagnait la Navarre et l'Aragon par voie de terre. Le gouvernement voulant fermer aux Hollandais l'entrepôt de Bayonne, afin de favoriser l'exportation du cacao des îles en Espagne, les marchands bayonnais protestèrent, assurant que pour trouver un débouché, le cacao des îles devait être mélangé de deux-tiers de cacao de Caraque; ce qui semble donner raison aux fidèles du chocolat vénézuelien. La création en 1718 de la Compañía de Caracas qui reçut de Philippe V le privilège du commerce avec la côte vénézuelienne, fermait au cacao martiniquais le marché espagnol. Heureusement, il restait la contrebande, activité favorite des Basques, et surtout en 1717 le droit d'entrée en France du cacao des îles était abaissé à 2 sols la livre, ce qui le rendait accessible a tous. Dès lors, la prospérité des plantations martiniquaises semblait assurée. Nous connaissons grâce toujours au P. Labat l'aspect des cacaoyeres de cette époque:

ablie sur des terres vierges, soigneusement sondées au préalable
in de s'assurer de la profondeur du sol arable, de préférence
ns une vallée arrosée par une rivière et coupée de ruisseaux,
tourée de lisières d'orangers, de corossoliers, de bananiers ou
figuiers pour la protéger du vent, une cacaoyère ne devait pas
surer plus de 100 toises soit 200 mètres de côté, on pouvait y
anter 5.625 arbres espacés de 8 pieds et disposés en quinconces;
s fosses à manioc dans les allées abritaient du soleil les jeunes
usses et empêchaient la croissance des mauvaises herbes fatales
x jeunes cacaoyers. Il fallait attendre quatre ans pour que le
ne cacaoyer atteignit sa pleine vigueur; il produisait alors
ux récoltes, une à la Noël, l'autre à la Saint-Jean. Entre 5 et
ns il donnait environ 2 livres et demie d'amandes par an. Sans
ute exigeait-il des soins continuels, était-il très sensible aux
uvaises herbes, aux insectes et aux ouragans, mais il était d'un
pport supérieur à celui du sucre: 50.000 pieds de cacao donnaient
effet pour le moins 100.000 livres d'amandes soit 37.500 francs
an, produit presque net, 15 à 20 esclaves, d'un entretien minime
ffisant à cette culture et pouvant en outre cultiver du manioc,
s ignames, etc.

Cueillies quatre mois après la chute des fleurs, les fèves
aient mises trois jours à sécher, après quoi on les grillait
ur en enlever la peau, on les pilait dans des mortiers de bronze,
marbre ou de gayac, on achevait de broyer la pâte sur une pierre
ncave avec un rouleau de fer, de marbre ou de gayac, après quoi
en formait des pains que l'on enveloppait dans du papier ou des
uilles. Ces opérations se pratiquaient encore récemment peut-être
pratiquent-elles toujours exactement de la même façon, dans la
ion de Rivière-Pilote et du Vauclin. On sent que le P. Labat se
rlèche les babines en évoquant la préparation du chocolat, les
rédients qu'on peut y mêler, les mélanges dans lesquels il peut
rer, le beurre de cacao, le cacao confit, la crème de la pulpe,
infusions de cacao, les massepains de cacao et de noix d'acajou.
semble bien que certains Dominicains ne le cédaient guère au Ca-
in des Anses-d'Arlets en gourmandise.

Le marché français étant largement ouvert et le chocolat s'étant
nitivement imposé, les cacaoyères se multiplièrent à la Marti-
ue fixant les habitants dans la Capesterre et dans les régions
ignées de la mer ou impropres à la culture de la canne. Le Gros-
ne, déjà existant comme quartier en 1694, fut le centre de cette
ure. Les exportations vers la France, inexistantes jusqu'à la
du XVIIème siècle, atteignirent en 1710, 7900 quintaux, tandis
celles de Saint-Domingue étaient à peine de 189 quintaux; pen-
les six premiers mois de 1717, 71 vaisseaux partis de Saint-
re amenèrent en France 9.361 quintaux de cacao; 1722 s'annonçait
e une année particulièrement brillante, déjà 13.776 quintaux
ent été exportés, quand, le 7 novembre un ouragan accompagné
tremblement de terre détruisit plus de six millions de pieds

sur les 14 millions que comptaient les plantations martiniquaises, et endommageait les autres, tandis que le pourridié les attaquait. Ce fut une chute terrible, et dont les planteurs ne se relevèrent que grâce à la culture du café. Tombées à 454 quintaux en 1733 les exportations ne repartirent qu'après 1740 pour se maintenir jusqu'en 1753 aux environs de 5.000 quintaux. L'introduction d'une espece nouvelle venue de Cayenne permit de reconstituer en partie les plantations. Après une nouvelle défaillance en 1765, la Martinique exporta, bon an mal an, 10.000 quintaux à la fin de l'Ancien Régime. On calcule qu'en 1775, les cacaoyères couvraient environ 800 hectares; cette même année, la Martinique fournissait à la France 9.300 quintaux sur les 15.000 que recevait la Métropole des colonies. Le rapport en atteignait cependant à peine le sixième de celui fourni par le café.

Le XIXeme siècle vit encore s'accentuer la décadence du cacao martiniquais: les exportations ne dépassèrent guère une moyenne de 300 tonnes annuelles soit environ 6.000 quintaux, pendant tout le Second Empire. En 1860, la surface plantée en cacaoyers était réduite à 212 hectares. Les encouragements et les efforts ne manquèrent pas cependant: c'est ainsi qu'en 1855, le Gouverneur Amiral de Geydon, ayant décidé de créer sur l'ancien Camp des Pitons un bourg auquel, en l'honneur de la victoire française de Crimée, il donna le nom de l'Alma, établit un projet de concession de terres domaniales: chaque concession devait être plantée par un tiers de café et de cacao, les deux autres tiers pouvant être consacrés à des cultures vivrières, ou laissés en savane. Une habitation domaniale située au même endroit devait également être plantée en cacao et en café: ce projet n'aboutit d'ailleurs pas. A la fin du siècle dernier, la culture du cacao sembla reprendre, grâce aux efforts de Thierry, chef des services agricoles: en 1895, 1.785 hectares plantés permirent à la Martinique d'exporter 732 tonnes, chiffre jamais atteint depuis le désastre de 1727. Mais l'éruption de 1902 fut fatale aux cacaoyers du Prêcheur et la décadence s'accentua.

RESUME

Un compte rendu de l'histoire de la culture du cacaoyer en Martinique est donné en détail. La narration commence par la description des premiers cacaoyers par Rochefort en 1647, et l'établissement d'une première plantation de cacao par un juif portugais, Benjamin Dacosta, en 1660. Une allusion est faite au premier commerce du cacao en Martinique en 1685. Bientôt on exporta de petites quantitées de cacao vers la France. A cette époque le cacao donnait des rendements bien supérieurs à ceux du sucre.

Gros-Morne fût le centre de cette culture et en 1710, les exportations du cacao vers la France atteignirent 7900 quintaux, ceui fût bien superieur aux exportations de Saint-Domingue.

1722 s'annonçait comme particulièrement brillante, mais un ouragan accompagné d'un tremblement de terre détruisit plus de six millions de pieds sur les 14 millions que comptaient les plantations martiniquaises.

Le 19ème siècle vit encore s'accentuer la décadence du cacao martiniquais.

RESUMEN

Se hace una descripción del cultivo de cacao en Martinica. La narración empieza con la descripción de los primeros árboles de cacao por Rochefort en 1647 y el establecimiento de una primera plantación de cacao por un judío portugués, Benjamin Dacosta, en 1660. Se hace alusión a un primer comercio de cacao en 1685. Pronto se exportaban pequeñas cantidades de cacao hacia Francia.

En aquella época, el rendimiento que daba el cacao era superior a aquel de la caña.

Gros-Morne era el centro del cultivo y en 1710 las exportaciones alcanzaron 7400 quintales. Esta cantidad fué superior a la de Santo Domingo.

1722 se anunció particularmente promisorio, pero un huracán acompañado de un terremoto destruyó 6 de los 14 millones de árboles existentes en Martiníca.

En el siglo diez y nueve aumentó aun la decadencia del cacao en Martiníca.

SUMMARY

The cacao industry of Martinique is described. The first cacao trees introduced by Rochefort in 1647 are described. The first plantation was established by Benjamin Dacosta, a Portuguese Jew, in 1660. Cacao first entered commerce in 1685, and small quantities were soon exported to Spain. Cacao was more profitable than sugar cane.

By 1710 the main center of cultivation was Gros-Morne, and exports reached 7,900 quintales, more than the production of Santo Domingo. In 1727 a hurricane and an earthquake destroyed 14 million trees, and the decline in cacao production which followed continued in the 19th century.

SUMMARY OF DISCUSSION

Dr. T.W. Tinsley (WACRI)

I have been very interested in this paper. It is the first time that I have heard a paper on this subject at a Cocoa Conference. I am aware that at the 7th Conference in Colombia one historical paper was included.

I would like to suggest that at the next Conference a session is devoted to the History of Cocoa Cultivation. I am interested in such studies in Africa and it is not long before one turns to the New World as a source. I would like to second the earlier request of Dr. Quesnel for information on cocoa cultivation in the New World. I also hope that our New World colleagues will be stimulated to write up histories of their own countries. This is particularly important as they will have access to information not normally available to us.

Finally, may I suggest to M. Goyeneche that his paper would have been more valuable if he had included references. Perhaps he could do this for the Proceedings.

Dr. V.C. Quesnel (Trinidad)

I should like to support Dr. Tinsley's plea for a historical session at the next Conference.

Regarding Mr. Goyeneche's paper, there are difficulties in the way of accepting Benjamin Da-costa as the "father of the cacao industry" in Martinique. Mr. Goyeneche accepts Labat's account but Labat is not altogether reliable. For example, he is the originator of the error that sugar cane grew in the New World before Columbus' voyage. I prefer to trust archival records. In two censuses of the Jewish population in Martinique which may be found in the French archives there appear a Benjamin Da-costa with his wife and family. In the first of 1680 his age is given as 29, in the second of 1682 as 35. Thus assuming the two entries to refer to the same individual (which seems very probable) he would have been about 13 years old in 1660 when he is supposed to have begun cacao cultivation. In 1654 when he was supposed to have arrived in Martinique with Jewish refugees from Brazil he would have been only seven. He could hardly have been travelling alone, so why is there no reference to his parents? Perhaps his father was the original cultivator of cacao and died before the census of 1680. This is a possible way out of the difficulty.

There is another version of the story, and that is that Da-costa introduced to Martinique a high-yielding variety of sugar cane but according to the census record he could have been only about 3 years old in 1650 when he is supposed to have done this. Yet in one way this is a more plausible version in that the Jews in Brazil at the time were cultivating sugar cane intensively but were not growing cacao.

RECOMMENDATIONS

A. RECOMMENDATIONS OF PREVIOUS CONFERENCES

Previous Inter-American Cacao Conferences have made a large number of recommendations. The Inter-American Cacao Center was given the responsibility of implementing most of these, but with its limited resources has not been able to do so in all cases. It was therefore decided to review the recommendations and the present position with regard to their implementation, with a view to establishing priorities. As a result of these deliberations, the following recommendation was adopted:

I. This Conference notes with satisfaction the accomplishment of many of the recommendations of former Inter-American Cacao Conferences.

II. After considering:

a) investigations already in progress, and

b) the research potential available, and

c) the difficulties of consultation in the period between conferences;

the Conference reaffirms the need for further information on and attention to the following:

1. That the usefulness to the plant-breeder of the most promising methods of small-scale fermentation be assessed.

2. That the assistance of chocolate manufacturers be solicited in establishing standard criteria of quality.

3. Increased attention to research on Phytophthora and Monilia.

4. Continued collection of data on the soils, vegetation, geology and meterology of all areas producing and capable of producing cacao.

5. That more and closer cooperation be established between international organizations (ICA, IAIAS, FAO, etc.) which are now providing technical assistance in cacao extension.

B. PLANT INTRODUCTION AND QUARANTINE MEASURES

I. Statement of Problem

1. Cacao improvement programs in all countries can move forward most efficiently only if they have access to the widest possible range of plant materials.

2. There is an ever-increasing tendency for movement and exchange of plant materials between countries and areas in order to meet the needs of national and regional programs.

3. Such exchanges are to be encouraged provided they can be made through proper channels and with benefit of good phytosanitary measures.

4. These exchanges, if made without safeguards, can be a means of spreading dangerous diseases and pests.

5. These exchanges cannot be stopped, even if it were desirable to do so. They will continue in dangerous and uncontrolled ways, if safe ways are not available.

6. Based on existing knowledge, the diseases of primary concern are Witches' Broom, Monilia Pod Rot and virus diseases. Less important are Cushion Gall and Ceratostomella. Pseudococcus spp. (as vectors of virus diseases); and Capsids are the insects at present considered to be most damaging to cacao.

It is therefore agreed that quarantine facilities are needed which will eliminate the likelihood of disseminating diseases and pests to areas not now infested; that these facilities should be situated in a place suitable for efficient operation, and that they should complement and strengthen national phytosanitary regulations.

II. Some currently available quarantine facilities

The following countries have been handling international shipments of cacao material, presumably mainly for those countries and territories most closely associated with them:

1. Belgium
2. France
3. Netherlands
4. Portugal
5. United Kingdom
6. United States of America

Quarantine measures against virus diseases will not be adequate unless procedures for examination of the plant material are under control of a qualified virologist.

There is an urgent need for a properly equipped, staffed and supported international cacao quarantine station where virus indexing and other diseases or pest quarantine problems can be safely handled, and for safe assemblage, quarantine and distribution of useful germplasm including the output from new plant collecting efforts.

III. Bases for recommendations

The following table indicates the present situation with regard to presence or absence of certain diseases in the countries listed. It is pointed out that few surveys for virus diseases have been made and that they may be present in more countries than indicated.

Countries	Monilia Pod Rot	Witches' Broom	Virus Diseases
Brazil			
Amazon area		X	
Rest of Brazil			
British Honduras			
Ceylon			X
Colombia*	X	X	?
Costa Rica			?
Cuba			
Dominican Republic			?
El Salvador			
Ecuador	X	X	
Grenada		X	
Guatemala			
The Guianas		X	
Haiti			
Honduras			

Countries	Monilia Pod Rot	Witches' Broom	Virus Diseases
Indonesia			?
Mexico			
New Guinea and other South Pacific areas			
Nicaragua			
Panama	X		
Peru		X	
Philippine Republic			
Tobago[36]		X	
Trinidad		X	X
Venezuela	X	X	X
All other West Indian areas			
West Africa			X

[36] Parts are free from Witches' Broom

Cushion Gall apparently is present in all cacao growing countries, in some being very prevalent, in others not commonly found.

Although Phytophthora palmivora is believed to be present in all cacao producing areas, there are localized strains, dissemination of which must be guarded against.

IV. Recommendations

1. All movement of any cacao propagating material from any area to any other should be done only with the advice, approval and guidance of qualified specialists in the area of origin and in the receiving area.

2. Seeds may be safely moved from any country or area to any other provided they are extracted from the pods and packed and treated according to methods now known (See Cacao, Vol. 3, No. 16, p. 29 and Vol. 3, No. 14) and with the qualifications stated under No. 1 above.

3. Vegetative material should be moved as budwood in all cases rather than as rooted cuttings.

4. Vegetative material may be moved as budwood from disease-free areas but should be given a post-entry quarantine treatment under the kind of supervision mentioned under No. 1 above.

5. Vegetative material of any kind should not be moved from any infested areas to disease-free areas except through intermediate and post-entry quarantine procedures and under the precautions mentioned under No. 1 above.

6. Pathologists and entomologists should report immediately to the IAIAS any changes in the table presented and any other pertinent information which may affect safety of plant material movements.

7. Cacao producing countries are urged to cooperate in supporting, developing and using fully adequate international cacao quarantine facilities and germplasm collections.

8. Producing countries should promote and support the assemblage, evaluation and inventory of superior and useful cacao germplasm which may occur within their own boundaries.

9. Producing countries should cooperate with FAO in carrying out the recommendations of the First FAO Technical Cacao Conference held in Ghana in February, 1959.

10. The Secretary General of the Inter-American Technical Cacao Conference should call the attention of OIRSA to the occurrence of Monilia Pod Rot in southeastern Panama and to the dangers of its movement into Central America.

THE INTERNATIONAL REGISTER OF CACAO CULTIVARS

It is recommended that:

1. That it is necessary to have a Register of Cacao Cultivars

2. That the Register shall be known as the International Register of Cacao Cultivars (Varieties).

3. That the Inter-American Cacao Center, Turrialba, Costa Rica, be appointed as the Registration Authority.

4. That the Inter-American Cacao Center be asked to obtain funds from international sources such as ICA, FAO, and ACRI for financing the International Register and for publishing descriptions of varieties.

5. That the Register be conducted under the rules laid down in the "International Code for the Nomenclature of Cultivated Plants".

A committee was appointed to formulate a system of descriptions of cultivars. The committee comprises the following persons:

B.G.D. Bartley
E.T. Bullard
A. Helfenberger

D. THE HISTORY OF CACAO CULTIVATION

The Conference recommends that a special session on the History of Cacao Cultivation be included in the Ninth Inter-American Cacao Conference.

E. FLUCTUATIONS IN CACAO PRICES

This Conference considers that large fluctuations in price between seasons give rise to serious misgivings in producer countries and that any further fall in prices might lead not only to indifference in care and maintenance of established plantings, but also a reluctance to enter into or continue with rehabilitation and development schemes. The Conference therefore recommends that the Secretary General inform the Cocoa Study Group of the Committee on Commodity Problems of FAO of the deep concern of cocoa producers on this matter and requests that the Study Group give urgent attention to this pressing problem, and consider undertaking further investigation into the possibilities of methods which would assist the long term-plans of development and rehabilitation in time for consideration at the next meeting of the Cocoa Study Group in March 1961.

RESOLUTION

This Conference has been impressed with the work being done by the ICTA at River Estate and by the Department of Agriculture at Centeno and Marper. The collection of planting material, the long-term field tests and the fundamental work on cocoa growing is of the first importance to cocoa growers, not only in Trinidad, but in many other parts of the world. This Conference considers that the continuity of the work at all those stations will keep Trinidad in the forefront of cocoa research throughout the world for many years to come.

RECOMENDACIONES

A. RECOMENDACIONES DE CONFERENCIAS ANTERIORES

En Conferencias Inter-Americanas de Cacao anteriores se ha hecho un gran numero de recomendaciones. El Centro Inter-Americano de Cacao ha recibido la responsabilidad de llevar a cabo la mayoría de éstas, pero con sus recursos limitados no ha sido capaz de realizarlas en todos los casos. Se decidió por tanto revisar las recomendaciones y situación actual en referencia a su cumplimiento con el fin de establecer prioridades. Como resultado de estas deliberaciones, se adoptó las siguientes recomendaciones:

I. Esta Conferencia nota con satisfacción el cumplimiento de muchas de las recomendaciones de Conferencias Inter-Americanas de Cacao anteriores.

II. Despues de considerar:

a) Las investigaciones ya en progreso, y

b) El potencial de investigación disponible, y

c) Las dificultades de consulta en los períodos entre conferencias;

la Conferencia se afirma la necesidad de información adicional sobre y la atención a lo siguiente:

1. Que se evalúe la utilidad al fitogenetista de los métodos más promisorios de fermentación en pequeña escala.

2. Que se solicite la colaboración de los fabricantes de chocolate para establecer criterios uniformes de calidad.

3. Que se dé mayor atención a la investigación sobre Phytophthora palmivora y Monilia Roreri.

4. Que se continúe la colección de datos sobre suelos, vegetación, geología y metereología de todos las areas que producen o son capaces de producir cacao.

5. Que se establezca mejor y mas estrecha cooperación entre las organizaciones internacionales (ICA, IICA, FAO, etc.) que actualmente dan ayuda técnica en extensión en cacao.

B. MEDIDAS PARA LA INTRODUCCION Y CUARENTENA DE PLANTAS

I. Presentación del Problema

1. Los problemas de mejoramiento de cacao en todos los países podrían progresar más eficientemente si tienen acceso al mayor rango posible de material de cacao.
2. Existe una tendencia siempre creciente de transportar e intercambiar material de cacao entre países y areas para satisfacer las necesidades de programas nacionales y regionales.
3. Se debe fomentar estos intercambios siempre que se hagan através de las vías adecuadas y con buenas medidas fitosanitarias.
4. Si estos intercambios se hacen sin las medidas adecuadas podrían ser el medio de diseminar enfermedades y pestes peligrosas.
5. No se puede detener esos intercambios aún si esto fuera deseable. Estos continuarán por caminos peligrosos y descontrolados, si no existen disponibles vías seguras.
6. En base al conocimiento actual, las enfermedades de primera importancia son Escoba de Bruja, Monilia y las enfermedades virosas. Son menos importantes las Agallas (Cushion Gall) y Ceratostomella. Los insectos que se consideran como los más dañinos a cacao son Pseudococcus spp. (como vector de las enfermedades de virus) y los Cápsidos.

Por lo tanto se estuvo de acuerdo en que se necesita facilidades de cuarentena que eliminarán la probabilidad de diseminar enfermedades y pestes a areas no infestadas; que estas facilidades deben estar localizadas en algun sitio adecuado para operación eficiente, y que estas deben complementar y robustecer las regulaciones fitosanitarias nacionales.

II. Algunas facilidades de Cuarentena Disponibles a la presente

Los siguientes países han estado realizando envíos internacionales de material de cacao, presumible y principalmente para aquellos países y territorios más cercanamente asociados con ellos.-

1. Bélgica
2. Estados Unidos de América
3. Holanda
4. Inglaterra
5. Francia
6. Portugal

Las medidas de cuarentena contra enfermedades virosas no serán adecuadas a menos que el proceso de inspección de material de plantas éste bajo el control de un virológo calificado.

Hay necesidad urgente de una estación de cuarentena internacional para cacao adecuadamente equipada y con personal competente en donde se pueda determinar la comprobación de virus y otros problemas de cuarentena de enfermedades y pestes, y para colección, cuarentena y distribución seguras del germaplasma útil incluyendo el material de nuevos esfuerzos de colección de plantas.

III. Bases para las Recomendaciones

El cuadro siguiente indica la situación actual en referencia a la presencia o ausencia de ciertas enfermedades en los países citados. Se anota que se han hecho pocos reconocimientos para enfermedades virosas y que éstas pueden estar presentes en más países que los indicados.

Países	Monilia	Escoba de Bruja	Enfermedades Virosas
Africa Occidental			X
Brasil			
Area del Amazonas		X	
Resto de Brasil			
Ceilán			X
Colombia*	X	X	?
Costa Rica			?
Cuba			
El Salvador			
Ecuador	X	X	
Filipinas			
Grenada		X	

- sigue ..

Países	Monilia	Escoba de Bruja	Enfermedades Virosas
Guatemala			
Guayanas			
Haití			
Honduras			
Honduras Británica			
Indonesia			?
México			
Nicaragua			
Nueva Guinea			
y Otros países del Pacífico Sur			
Panamá	X		
Perú		X	
República Dominicana			?
Tobago*		X	
Trinidad		X	X
Todo el resto de las Indias Occidentales			
Venezuela	X	X	X

*Sitios que no tienen Escoba de Bruja

Las agallas (Cushion Gall) están aparentemente presentes en todos los países que cultivan cacao, en algunos son muy prevalentes y en otros no se las encuentra comunmente.

Aun que se cree que Phytophthora palmivora está presente en todas las areas productoras de cacao, hay razas localizadas cuya diseminación debe prevenirse.

IV. Recomendaciones

1. Todo movimiento de cualquier material de propagación de cacao de cualquier area a cualquier otra debe hacerse solamente con consejo, aprobación y dirección de especialistas calificados en el area de orígen y en la de recepción.

2. Se puede transportar sin peligro semillas de cualquier país o area a cualquier otro siempre que se las extraiga de mazorcas y se las empaque y trate de acuerdo con los métodos actualmente conocidos (Vea Cacao, Vol. 3, No. 16, p. 29 y Vol. 3, No. 14) y con las calificaciones establecidas bajo el numeral 1 anterior.

3. El material vegetativo se debe transportar en todos los casos en forma de varetas para injertos antes que como estacas enraizadas.

4. El material vegetativo puede transportarse como varetas para injertos desde areas libres de enfermedades pero se debe dar un tratamiento de cuarentena posterior a su entrada bajo la clase de supervisión mencionada en el numeral 1 anterior.

5. Ninguna clase de material vegetativo debe ser transportado de una zona infectada a areas libres de enfermedades excepto através de procedimientos de cuarentena intermedia y posterior y bajo las precauciones mencionadas bajo el numeral 1 anterior.

6. Los patólogos y entomólogos deberían informar inmediatamente al IICA cualquier cambio en el cuadro presentado y cualquier otra información pertinente que pueda afectar la seguridad de los movimientos de material de plantas.

7. Se solicita a los países productores de cacao cooperar en apoyar, desarollar y usar enteramente las facilidades de cuarentena internacional de cacao y las colecciones de germaplasma.

8. Los países productores deberían promover y apoyar la recolección, evaluación e inventario del germaplasma superior y útil que pueda existir dentro de sus fronteras.

9. Los países productores deben cooperar con FAO para cumplir las recomendaciones de la Primera Conferencia Técnica de Cacao de FAO, realizada en Ghana en febrero 1959.

10. El Secretario General de la Conferencia Técnica Inter-Americana de Cacao debe llamar la atención de OIRSA sobre la ocurrencia de Monilia en el Sureste de Panamá y sobre los peligros de su avance hacia Centro América.

C. EL CATALOGO INTERNACIONAL DE CULTIVARES DE CACAO

Se recomendó que:

1. Es necesario tener un Catálogo de Cultivares de Cacao.

2. Que el Catálogo se conocerá como "Catálogo Internacional de Cultivares (Variedades) de Cacao".

3. Que se nombre al Centro Inter-Americano de Cacao, Turrialba, Costa Rica, como autoridad de registro.

4. Que se pida al Centro Inter-Americano de Cacao que obtenga fondos de fuentes internacionales como ICA, FAO y ACRI para financiar el Catálogo Internacional y para publicar descripciones de las variedades.

5. Que el Catálogo sea elaborado de acuerdo a las reglas propuestas por el "Código Internacional de Nomenclatura de Plantas Cultivadas".

Se nombró un comité para formular un sistema de descripción de cultivares. El comité incluye las siguientes personas:

B.G.D. Bartley
E. T. Bullard
A. Helfenberger

D. LA HISTORIA DEL CULTIVO DEL CACAO

La Conferencia recomienda que se incluya una sesión especial en la Novena Conferencia Inter-Americana de Cacao sobre la historia del cultivo del cacao.

E. FLUCTUACIONES EN LOS PRECIOS DEL CACAO

Esta Conferencia considera que las grandes fluctuaciones de precios dan origen a serias preocupaciones en los países productores y que cualquier otra caída de los precios puede acarrear no solamente una indiferencia en el cuidado y mantenimiento de plantaciones ya establecidas, sino también una resistencia en empezar o continuar programas de rehabilitación y desarrollo. La Conferencia por tanto recomienda que el Secretario General informe al Grupo de Estudios de Cacao del Comité de Productos de la FAO, acerca de la profunda preocupación existente entre los productores de cacao sobre este punto, y solicita que el Grupo de Estudios conceda atención urgente a este creciente problema, así como de tomar a su cargo la investigación de las posibilidades y métodos que podrían constituir una ayuda en los planes a largo plazo sobre rehabilitación y desarrollo para ser considerados en la próxima reunión del Grupo de Estudios de Cacao en marzo de 1961.

RESOLUCION

Los delegados de la Conferencia han tenido la mejor impresión del trabajo que el ICTA está realizando en River Estate y el Departamento de Agricultura en Centeno y en Marper. La colección de tipos de cacao, los experimentos de campo a largo plazo y los trabajos fundamentales en el crecimiento del cacao son de primera importancia para los cultivadores, no solamente de Trinidad, sino de muchas otras partes del mundo. Esta Conferencia considera que la continuación de estos trabajos en todas estas estaciones mantendrá a Trinidad como lider en investigaciones de cacao en todo el mundo por los años venideros.

FIELD EXCURSIONS

Visit to the Imperial College of Tropical Agriculture

17 June, 1960

The Imperial College of Tropical Agriculture was founded in 1921 as the centre for training and research for the British Commonwealth. In the past it has offered courses at under-graduate and post-graduate levels leading to Diplomas. As from 1st August 1960, ICTA is to be merged with the University College of the West Indies in Jamaica and will become its Agricultural Faculty.

The research activities are centred in the Regional Research Centre which resulted from combining three previous research schemes viz. cacao, banana breeding and soils research. The R.R.C. has expanded to cover other lines of research.

The work on cacao falls under the following heads:- plant breeding, plant physiology and biochemistry, soils chemistry, plant pathology and entomology. As land for field experiments is limited around the College most of the field work is done at River Estate and the more recently acquired Las Hermanas sub-station.

The party visited: the Library; the Sir Frank Stockdale laboratories which house the botanical, plant pathological and entomological sections and the herbarium of Trinidad plants; the plant physiology and biochemical section where the equipment for the preparation and manufacture of small samples of chocolate for tasting; a laboratory procedure for micro-fermentation and small scale drying; the main physiology laboratory; and the analytical laboratory for analysis of leaf samples were seen.

Several field experiments were visited:

1. Stock Scion Trial. This involves the interaction of 4 clones ICS 1, 45, 60 and 95 in all 16 combinations of scion and stock. Yield of a poor clone is improved by a vigorous stock and the converse also holds good. There is no interaction between stock and scion and no combination has given higher yields than the best clone on its own roots. The field was originally planted at 12 x 6 ft. and was thinned to 12 x 12 ft.

2. Soil cover experiment. To investigate the effect of soil water logging in the wet season the soil is covered with water proof paper that spills most of the rain into the drains. This is combined with and without dry season irrigation. There is also an irrigation treatment only and a control. Over three years differences in yield have been small and non-significant. Spacing is 7½ ft. and no shade trees are used.

3. Training experiment. Various systems of pruning and shaping young cocoa including training as cordons. The general conclusion is that too early drastic pruning reduces yields.

4. Field B. Some of the oldest field plantings of rooted cuttings. ICS 1, now 20 years old, is almost indistinguishable from a seedling. Spaced 12 x 6 ft. with no overhead shade. This small plot has given over a ton an acre in one season. This field also contains a small plot of hybrid seedlings and cuttings of the SCA and ICS parents.

In process of construction are three controlled-environment growth rooms. It is proposed to investigate the cycles of flushing, flowering and fruiting in relation to temperature, humidity and light.

The various systems of propagation in use, including closed bins, open spray beds and a centrifugal humidifier, were demonstrated. The unit produces 6-8000 plants per year mostly for experimental purposes.

The method of artificial inoculation of 4 day old seedlings to screen plants for resistance was seen. Present facilities and techniques enable 12,000 plants to be treated each year.

In the Soils Department a display of maps in connection with the soil survey work in the British Caribbean and the Analytical Laboratory were visited.

Visit to Roxborough Fermentary, Tobago

18 June, 1960

It is a recognised fact that the small producer of cacao has difficulty in processing and handling the small batches of cacao that he reaps. In Trinidad and Tobago the small grower often realises much lower prices for his finished product than would be possible if his product was well prepared. On the recommendation of the late Dr. C. Y. Shephard, Co-operative Fermentaries were established in Tobago from 1929. Today three survive - at Roxborough (established 1932) Pembroke (1929) and Delaford (1934). They have established through their endeavour that the small grower, collectively, can produce a good product. Their finished cocoa is marketed through the Cocoa Planters Association and as such realises a price equivalent to the best Trinidad cacao.

It should be stressed that the success of these co-operative fermentaries can be attributed to:-

1. The members are known to each other and live in a compact area.
2. The original members had a financial interest, having advanced funds for buildings, etc.
3. They are organised and registered through the Co-operative Department of Government.
4. They have had the benefit of technical advice from the Department of Agriculture and from large planters in the area (notably Mr. K. Reid and Mr. Mayow Short)

The production and price obtained for finished cocoa is shown below.

Prices obtained and quantities of dry cocoa delivered to the Cocoa Planters' Association of Trinidad Ltd. by Cocoa Fermentaries in Tobago

Year	CPA Price $ per Fanega (100 lbs)	Pembroke lb.	Roxborough lb.	Delaford lb.
1930/31	7.60	32,344		
1931/32	7.35	32,562	18,334	
1932/33	5.78	57,319	46,943	
1933/34	6.21	42,134	28,866	
1934/35	6.05	79,583	68,118	26,430
1935/36	7.00	49,327	68,379	23,209
1936/37	13.09	38,643	76,231	23,641
1937/38	6.71	65,895	132,809	42,138
1938/39	6.50	42,844	46,875	17,751
1939/40	10.34	75,470	85,331	31,404
1940/41	9.90	71,622	88,682	31,650
1941/42	14.08	49,936	46,885	20,153
1942/43	13.20	45,743	41,350	21,788
1943/44	14.41	53,165	58,180	24,845
1944/45	14.85	43,151	48,085	19,366
1945/46	15.51	28,563	39,464	16,776
1946/47	34.92	38,318	47,899	9,717
1947/48	47.30	51,728	64,349	17,470
1948/49	36.30	33,562	38,772	13,376
1949/50	47.63	44,700	42,084	17,214
1950/51	67.65	27,951	23,244	15,713
1951/52	59.40	25,280	26,666	15,525
1952/53	55.00	38,372	38,453	28,670
1953/54	80.30	21,476	20,925	16,645
1954/55	90.00	24,958	35,184	19,150
1955/56	55.00	31,783	45,779	38,455
1956/57	49.50	32,228	30,932	37,802
1957/58	72.60	44,070	54,159	51,919
1958/59	74.25	26,933	44,121	35,103

Visit to River Estate, Experiment Station of the Imperial College of Tropical Agriculture

21 June, 1960

An area of 420 acres is leased by the Government of Trinidad and Tobago to the Imperial College of Tropical Agriculture for 99 years. River Estate formerly embraced over 1600 acres, most of it sloping lands which have now come under the care of the Forestry Department and some rented to gardeners. Before being leased to ICTA, River Estate was for long an experiment station of the Trinidad and Tobago Department of Agriculture and it was here that some of the very earliest improvement work on cacao was initiated (selection of superior mother trees, followed by budding).

Cocoa virus has been troublesome at River Estate. Whilst the virus appears not to be lethal to its host, its presence in experimental plantings is highly undesirable and severely infected areas have been cleared and newly infected trees cut out when symptoms appear.

The series of experiments on fertilisers, mulches, soil cultivations and shade described in the paper "Cultural and Manurial Experiments at River Estate - A Review" by G.K. Maliphant, were seen. The extensive series of clonal trials and of trials and plantings of seedling progenies and hybrids were also visited. Other field experiments at River Estate include a stock/scion trial; an experiment to study the effect of size of plant at planting on later yield; an experiment on the effect of bark inversion on inducing early flowering and fruiting; studies of mutant cacao types; a trial on the foliar application of trace elements with particular reference to copper; investigations on self-pollination and on how far pollen is carried; and pruning trials.

Other Theobroma species and species of Herrania, and interspecific crosses were seen.

Visit to Cacao Areas in Central Trinidad

22 June, 1960

(A) Tortuga Estate - Montserrat District

This estate was one of the first to undertake a rehabilitation programme, commencing in 1943. To date some 115 acres have been completely replanted, of which some 85 acres were in production for 1958/59 crop.

It should be noted that this farm represents one of the best cocoa soils in Trinidad i.e. "chocolate soil", which is described as Montserrat Clay in the soil classification.

The main variety used is ICS 1. So far the only planted material in bearing is rooted cuttings. Yields have in general well exceeded 500 lbs. per acre by the sixth or seventh year and 1000 lbs. per acre by the eleventh or twelth year.

(B) Clonal and fertilizer experiments - Located at Poole Syndicate Estate, Rio Claro.

These experiments were laid down in 1952, being part of the series of trials described in the paper "Clonal & Fertilizer Experiments in Trinidad and Tobago" by A.L. Jolly and L.L. de Verteuil.

Soil Type - Princes Town Heavy Clay
Rainfall - 110" per annum (average)
Layout (Variety) - 2 incomplete blocks testing 21 varieties in each
Number of replications - 5
Plot size = 6 trees in one block
= 4 trees in one block
Spacing 9' x 9'
Guard rows of SCA 6 and SCA 12 separate the plots and act as pollinators.
Layout (Fertilizer) - 8 randomized blocks testing control and N-P-K
Plot size = 16 trees (8 of ICS 1
8 of ICS 95).

Visit to Central Experiment Station, Centeno, Trinidad

24 June, 1960

The cacao section at Centeno encompasses three old cacao estates, in total covering some 900 acres of which approximately 500 are in old seedling cacao. Work is carried out under three heads, viz:-

a) Cacao propagation
b) Commercial cacao production
c) Experimental work

Cacao Propagation

Total plant production in Trinidad and Tobago is at present 1½ million plants per annum of which the La Reunion Station accounts for 1/2 million. Recent production is shown below.

Year	No of plants	Production efficiency
1956	484,129	73%
1957	453,532	67%
1958	475,061	73%
1959	573,600	79%

The layout of the station is shown overleaf, comprising 18 standard units utilising the La Reunion method for vegetative propagation.

Commercial Cacao

Some 500 acres of old seedling cacao are operated as a commercial producing estate. This area was abandoned for twenty years during the depression. In 1954 this was brought back into cultivation by improving drainage, planting shade, removing wild trees and pruning the cacao. Some 40 acres have been partially replanted but the young trees are not yet in production. Crop production has been:

1959	86,331 lbs
1958	108,525 "
1957	88,468 "
1956	115,136 "
1955	82,125 "

The mean tree yield of old seedling cacao was 1-1/3 lbs dry cacao per annum.

Experimental Work

The main work comprises the obtaining of population data from hybrid crosses and the evaluation of individual selections in varietal trials. Some 75 acres have been planted in hybrid seedlings.

Visit to Marper Farm

24 June, 1960

Marper Farm was established by the Department of Agriculture in 1930 for the special purpose of investigating problems concerning Witches' Broom disease (Marasmius perniciosus). The first syllables of the scientific names of the fungus were combined to give the farm a suitable name.

The total acreage of Marper is 110 acres and it also has a commercial propagator which produces over 60,000 cuttings annually. The average rainfall of the area is about 110 inches and it was selected in an area where Witches' Broom disease is very prevalent. It is situated in the Manzanilla district some 45 miles distant from Port-of-Spain.

The first phase of the work was to investigate the possibility of selecting resistant clones within the local Trinitario population. Consequently in 1930 clonal material of trees which had been previously selected as being free from diseases were planted in rows. At the same time seedlings from these trees were also planted to investigate whether the resistance, if proved, would be transmitted to the seedling population.

These trees are planted in blocks A & B but the results were disappointing inasmuch as none of the clones showed a degree of resistance high enough for commercial use nor did the prospect of being able to breed resistant types from them appear hopeful.

It was decided that the only hope of getting resistant clones was to select material from the Amazon where the disease has been known for a long time and where it was more likely that some immunity had developed. Consequently excursions were made to the Upper Amazon by the late Dr. Pound at the time Cocoa Agronomist of the Department of Agriculture (1938-42), and open pollinated pods were collected from disease-free trees and sent to Barbados where they were germinated.

The second phase of the work at Marper thus consisted of the planting of clonal material from these seedlings. They were established in blocks C & D in 1939.

The main points of interest from these clones were:

1. They were all self-incompatible although many were cross-compatible.

2. All had unpigmented pods.

3. Many were very high yielding and suitable for distribution.

4. The average degree of resistance was much higher than found in Trinitario clones.

5. The highest degree of resistance came from clones from one pod - Scavina.

6. One of the Scavina clones, namely, SCA 6 appeared to be immune to vegetative and pod infection.

The finding that SCA 6 was immune was a very great step forward and led to the commencement of the third phase of the work. This consisted of using SCA 6 as a parent to investigate whether this immunity would be inherited and, if so, to produce some new hybrid clones which were immune but had larger pods and beans than SCA 6 which as a clone was unacceptable as a commercial clone because of its small pod and small seeds.

The seedlings were planted in 1950 at a spacing of 8' x 8' (680 trees per acre) and the following table shows yield in the last three years:

Parents	No Trees	Lb. Dry Cocoa Per Acre 1957	1958	1959
SCA 6 x ICS 1	326	1052	801	1432
SCA 6 x IMC 67	245	1040	809	836
ICS 1 x SCA 6	190	839	830	892

As far as disease was concerned it was found that the progeny of SCA 6 were not all immune - the actual figure was 3% immune in the cross SCA 6 x ICS 1 and 6% when SCA 6 was crossed with another fairly resistant Amazon clone namely IMC 67. The crosses between SCA clones gave no immune trees.

Although the cross SCA 6 x ICS 1 only produced 3% immune trees it did however produce a population which had a much higher average resistance than Trinitario cocoa. In its first six years after planting the average total number of vegetative brooms per tree was 31 while of the mature pods less than 1% were infected by Marasmius.

Although these seedlings had been planted to create a population from which commercial clones would be selected it was soon apparent that the seedling population was giving returns

comparable with that of existing clonal cocoa. The bean and pod weights while on the low side were acceptable. A sample of pods from each tree when six years old was taken and the average for the cross SCA 6 x ICS 1 was 9.5 pods to produce one pound dry cocoa with an average net weight per bean of 2.9 grs.

These results have created a very wide-spread interest in the commercial use of seedling cocoa from known crosses in which the Amazon clones must feature prominently as a parent.

From these crosses about 175 trees were selected for trial as clones and of these 21 were immune. These are being tested in observation line trials and may ultimately be distributed as clones or used as parents for further seedling populations. Many had bean weights of over 4 grs. wet and pod indices of 7.

A further group of seedlings was planted in 1953 from pods of 20 of the selected hybrid trees. They were spaced 8' x 12' (454 trees per acre). The field yield of these in 1959 was 627 lb. dry cocoa per acre with the best plot yielding 1200 lbs.

In no plot was the amount of vegetative brooms or diseased pods excessive so that it appeared probable that we would ultimately be able to replace SCA 6 by one of our new immune hybrids and so get seedling populations with more attractive bean and pod weights.

The selections made from these populations were better than the F1 generation and an example of one of the best is TSAN 792, derived from TSA 644. At the end of four years in the field it has produced 51 good pods, 1 broom and 4% W.B. pods with a pod index of 5.7 and a bean weight of 3.9 wet.

The open populations from TSA 644 and TSA 641 were very satisfactory with total yields of over 600 lbs per acre at age 3 years and these two clones were also immune to Witches' Broom. These are now being tried extensively as parents in controlled crosses.

Many hundreds of crosses have now been made and these are planted in observation blocks in various parts of Trinidad. All these seedlings are recorded individually so that average population data can be calculated while at the same time clones can be selected for distribution or use as parents.

Clones which have originated from Marper Farm include:

SCA (Scavina) 6, 9, 12
PA (Parinari) 30, 46, 121, 150, 169, 221
P (Peru) 7, 18
NA (Nanay)
IMC (Iquitos) 59, 67
TS (Trinidad selected)
TSA (Trinidad selected Amazon) 641, 644
TSH (Trinidad selected Hybrid) 565
TSAN 792

CLOSING SESSION

SUMMING UP

Louis L. de Verteuil, Executive Chairman

I propose to make a brief summary of the proceedings of the Conference, and to call attention to what I consider the more significant points that have emerged from the papers presented and the discussions which ensued.

The number of papers presented totalled 53 of which 26 were in English, 19 in Spanish and 8 in French. By subject matter the breakdown was Breeding and Selection 5; Horticulture 11; Soils and Nutrition 7; Pests and Diseases 17; Fermentation and drying 3; Extension and Development 9; and Rehabilitation 1.

Breeding and Selection

We have listened with interest to the report presented by Dr. Bartley on the Breeding Seminar. The pooling of knowledge and exchange of ideas on this important subject was long overdue. The importance of the Upper Amazonian forasteros in providing improved plant material for the farmer was highlighted. The pioneer work of the late Dr. Pound, one time Cocoa Agronomist of the Trinidad Department of Agriculture, continues to bear abundant fruit. Has not the time come for further expeditions in the Amazon?

Horticulture and Growth Physiology

With the increasing emphasis on the use of seed as planting material, evaluating methods to preserve its viability over long distances by air, sea and land are of immediate concern. Methods of storing pollen and attempts to induce early flowering by manipulating photoperiod are of value in speeding up breeding work.

Soils and Nutrition

A welcome original contribution has come from Professor Homès of Brussels who has described a fresh approach to diagnosing fertiliser needs which should aid in the solution to this intricate problem. At the last Alliance Conference held in the United Kingdom, Mr. Paul Cadbury, in his summing up, called attention to the need for further work on this subject.

Pests and Diseases

The contributions from Pichilingue Station in Ecuador by Messrs. Ampuero, Alvarado and Doak were of great interest and value. The Silecia Scavina crosses hold promise for both high yield and Witches' Broom resistance.

It is encouraging to note that there is some evidence of clones resistant to Monilia roreri, a fungus disease of major importance in parts of South America.

At the last Inter-American Cacao Conference held in Colombia, there was a symposium on Ceratostomella, which emphasised the lack of data on this disease. The one paper presented on this subject has thrown new light on the problem, especially the relationship between the beetle and the fungus, and stimulated a valuable discussion. This could lead to practical methods of controlling this disease through control of the insects. There were nine papers on Cushion Gall, a disease condition which has recently come into prominence in the Western Hemisphere. It is not possible as yet to gauge to what extent, if any, Cushion Gall affects the yield of infected trees. It is of interest to note that in the Atlantic region of Costa Rica two United Fruit clones appear to be resistant.

Fermentation and Drying

The ultimate aim of the farmer is to prepare his product in such a manner as to bring out the full flavour of the bean. The present situation is best summed up in the words of Dr. Quesnel "let us face it, we do not know a great deal about chocolate flavour".

Extension, Development and Rehabilitation

There was an interesting description of extension work in Western Nigeria, whilst the activities of the Campaña Nacional de Cacao in Colombia were described by Ing. Monsalve. This was followed by a narrative on the history of cocoa growing in Martinique which led to a resolution to have a section devoted to the history of cocoa growing at the next Conference.

The paper on "Rehabilitation for the future" is of special interest to those countries which are faced with the problem of rehabilitating their cocoa industries on existing cocoa areas without new lands for development.

Simultaneous Interpretation

For the first time at these conferences we have had simultaneous interpretation. I have no doubt that it will become a feature of all future Inter-American Conferences. On behalf of the Conference I would like to pay tribute to the excellent job done by the two interpreters Carmen de Marino and Mercedes de Torres.

Before closing I would like to thank the Vice-Chairmen for their contribution to the success of the different sessions and finally to pay tribute to Mr. Gordon Havord, the Secretary General, for his monumental labour in organising this conference.

To all delegates and observers I would like to say what a stimulating experience it has been for me to chair this conference, and to congratulate everyone on the part they played. In particular, I would like to thank our friends from the Old World for gracing this conference with their presence, and for their many outstanding contributions. In truth, this has been a World Cacao Conference.

SUMMARY OF SPEECHES AT CLOSING SESSION

Dr. Jorge León, representing the Director of the Inter-American Institute of Agricultural Sciences, expressed the gratitude of the Institute and of the Conference to the Government and people of Trinidad and Tobago for the help and co-operation given to the Conference. He also extended thanks to the Imperial College of Tropical Agriculture for providing facilities for the Seminar on Cacao Breeding and Selection held immediately prior to the Conference, and to the College and to all the other organisations and individuals who had been hosts at the field excursions. He also expressed appreciation of the unstinted hospitality the delegates had been shown on all occasions. Dr. León said that in the two weeks they had been in Trinidad, the delegates had been impressed by the way people of many racial, cultural and religious backgrounds were uniting in building a new nation. They hoped the Government and people would have all success in the future.

The Secretary General thanked the Ministry of Agriculture and the Cocoa Board for their unfailing help and co-operation, and said that the Conference had been conducted in an atmosphere of helpful collaboration and co-operation. He also thanked the interpreters, the sound engineer and the secretarial staff for their hard work and unstinted co-operation.

Sr. Miguel Aspiazu (Ecuador), Mr. E. Quartey-Papafio (Ghana) and M. Jean Braudeau (France) all spoke on behalf of the delegates. All said that the Conference had been highly successful and extremely valuable, and complimented those responsible for the organisation. The three delegates spoke for all when they expressed their sincerest appreciation to the Government and people of Trinidad and Tobago for the friendly welcome they had received, for the overwhelming generosity and hospitality which had been showered upon them, and said that the Conference would always be a memorable occasion.

The Conference was formally closed by the Minister of Agriculture, Lands and Fisheries, the Hon. Kamaluddin Mohammed, who said the Conference was the first international one to be held in Trinidad and Tobago or in any part of the West Indies. One must not misunderstand the significance of the Conference, particularly having regard to world affairs.

The young Federation of the West Indies, he said, was now seeking independence, and Trinidad and Tobago had just been granted full internal self-government, although they were not yet living with it.

He hoped that with their prayers, their help and their support, they were going to be able to succeed, so that when Trinidad and Tobago became self-governing, and the Federation independent, they could occupy their seats side by side with the delegates' independent and great countries, to be able to play their part in the moulding of a prosperous and peaceful world.

The Minister said war clouds were hanging over their heads, but it was through conferences such as this, and through the exchange of friendship and goodwill, that they could play some little part in lessening the tensions of the greater countries, and form a balance between the greater powers.

It had been a great privilege and honour to Trinidad to be their host. He asked the delegates to convey to their respective governments and peoples the best wishes and greetings of the Government and people of Trinidad and Tobago, and wished them all good luck and Godspeed.

Government Press, Trinidad